SCENTS OF ARABIA

INTERDISCIPLINARY APPROACHES TO ANCIENT OLFACTORY WORLDS

Edited by

Arnulf Hausleiter and Barbara Huber

IASA
International Association for the Study of Arabia
الرابطة الدولية لدراسة الجزيرة العربية
Seminar for Arabian Studies

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Scents of Arabia: Interdisciplinary Approaches to Ancient Olfactory Worlds

Papers from a Special Session of the Fifty-fifth Meeting of the Seminar for Arabian Studies, held in Berlin on 6th August 2022

Edited by

Arnulf Hausleiter and Barbara Huber

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Guidelines and Transliteration

Guidelines for Authors

For details on the submission of papers and the preparation of papers for publication, authors are requested to consult and follow the latest *Guidelines for Authors.* These are available on the International Association for the Study of Arabia website at https://www.theiasa.com/seminar/publication/. Please contact the editors on https://www.theiasa.com/seminar/publication/ for further information.

Formatting

Electronic versions of papers being submitted for publication should be set in Times New Roman 12-point typeface if at all possible, with double-line spacing on A4-paper size and 2.45 cm margins all round.

The IASA System of Transliteration of Relevant Characters

Quotations, single words, and phrases from Arabic or other languages written in non-Roman alphabets, are transliterated according to the systems set out below.

- We firmly encourage authors to use the correctly transliterated form of any place name, but the names used for types of pottery, archaeological periods, and cultures which have become archaeological standards should be used in that form: Umm an-Nar, Julfar ware, etc. If any place name needs to be given in a non-standard format, the correctly transliterated form should be added in the first instance in any paper (see *Guidelines for Authors* for more details).
- Personal names, toponyms, and other words that have entered English or French in a particular form, should be used in that form when they occur in an English or French sentence, unless they are part of a quotation in the original language, or of a correctly transliterated name or phrase. In the latter cases, they should be correctly transliterated, even when they occur in an English or French sentence.

1. Arabic

ء	M	ج	j	ذ	dh (dh)	ش	sh (sh)	ظ	Ξ	ق	q	ن	n
ب	b	ح	ḥ	ر	r	ص	ṣ	ع	K	ك	k	ه	h
ت	t	خ	kh (kh)	ز	z	ض	ḍ	غ	gh (gh)	ل	l	و	w
ث	th (th)	د	d	س	s	ط	ṭ	ف	f	م	m	ي	y
Vowels		a i u ā ī ū		Diphthongs		aw	ay						

The underlined variants can be used to avoid any ambiguity, e.g. *lam yushir* vs. *lam yushir.*
Initial *hamzah* is omitted.
Alif maqṣūrah is transliterated as ā.
The *lām* of the article is not assimilated before the 'sun letters', thus the form should be *al-shams* but not *ash-shams*.
The *hamzat al-waṣl* of the article should be shown after vowels except after the preposition *li-*, as in the Arabic script, e.g. *wa-ʾl-wazīr*, *fiʾl-bayt*, but *li-l-wazīr*.
Tāʾ marbūṭah (ة) should be rendered *-ah*, except in a construct: e.g. *birkah*, *zakāh*, and *birkat al-sibāḥah*, *zakāt al-fiṭr*.

2. Persian, Urdu, and Ottoman Turkish
Please transliterate these languages using the system set out for Arabic above with the additional letters transliterated according to the system in the *Encyclopaedia of Islam* (http://referenceworks.brillonline.com/entries/encyclopaedia-islamica/system-of-transliteration-of-arabic-and-persian-characters-transliteration) except that ž is used instead of *zh*. There is a useful table to convert Ottoman Turkish to modern Turkish characters on http://en.wikipedia.org/wiki/Ottoman_Turkish_language.

3. Ancient North and South Arabian Consonants:

ʾ	b	t	t̲	ḥ	g	h̲	d	d̲	r	z	s¹	s²	s³	ṣ
ḍ	ṭ	ẓ	ʿ	ġ	f	q	k	l	m	n	h	w	y	

4. Other Semitic languages
Please use the transliteration systems outlined in the *Bulletin of the American Schools of Oriental Research* (BASOR) 262 (1986), p. 3. (www.jstor.org/stable/i258780).

Preface

This volume presents the contributions to the special session "Scents of Arabia: Interdisciplinary Approaches to Ancient Olfactory Worlds", which took place as part of the 55th Seminar for Arabian Studies on August 6, 2022 at Humboldt-Universität zu Berlin. We are pleased to publish most of the ten papers given at this very inspiring conference, which concluded with a panel discussion followed by a keynote lecture by Kiersten Neumann.

The editors join the International Steering Committee in thanking the organizers of 2022 Seminar, namely the International Association for the Study of Arabia (IASA), the German Archaeological Institute (DAI), the Humboldt University and the Museum of Islamic Art, as well as all associated institutions and colleagues, who are named in the foreword to the 2022 conference proceedings.

Arnulf Hausleiter would like to thank the German Research Foundation (DFG), Bonn, for approving a grant for this special session as part of the 'International Scientific Conference' funding programme.

This publication was made possible by the German Archaeological Institute (DAI) and the then Director of the Orient Department, Ricardo Eichmann, who provided a budget for the editorial work. Derek Kennet supported the publication process in the pre-print phase, while the International Committee of the Seminar enthusiastically accompanied the creation of the volume. Hanna Hamel took care of the editing, while Mike Schurer from Archaeopress, together with Erin McGowan, handled the typesetting and the cover design as smoothly as ever. Annika Busching kindly supported the final phase of the publication process. We are very pleased to present this publication as both an open access and a print publication. We would like to thank everyone involved in the production of this publication for their kind support. We include the two reviewers in these thanks for adding valuable comments.

Finally, we are indebted to the authors of this volume for their contributions to this interdisciplinary publication.

Berlin and Jena, July 2025

Arnulf Hausleiter, Barbara Huber

Titles of papers read at the Seminar for Arabian Studies special session

Scents of Arabia: Interdisciplinary Approaches to Ancient Olfactory Worlds

Held at the fifty-fifth meeting of the Seminar for Arabian Studies
Saturday 6 August 2022, Humboldt Universität zu Berlin

Part 1 *Conceptual Frameworks*

11:10 Arnulf Hausleiter (Berlin), Introduction to the Special Session

11:35 Sureshkumar Muthukumaran (Singapore), From and Beyond Arabia: Incense culture and resinous substances in the 1st millennium BCE Middle East and the eastern Mediterranean

12:00 Lunch

Part 2 *Practice and Use (Moderator: Marta Luciani, Vienna)*

13:10 Abdul Rahman Al Maashani (Muscat), Frankincense: From Scraping to Burning*

13:35 William G. Zimmerle (Abu Dhabi), Production of incense burners: ethnographic perspectives

Part 3 *Reconstructing Smells: New Insights (Moderator: Christine Kainert, Berlin)*

14:00 Elisabeth Dodinet (Paris), Archaeobotany and the reconstruction of scents

14:25 Barbara Huber** (Jena) et al., Beyond Frankincense: Exploring aromatic diversity in Arabia using biomolecular approaches

14:50 Sofia Collette Ehrich (Amsterdam), How Can We Smell History? – presenting and communicating olfactory histories within the cultural sector

15:15 Break

Part 4 *Incense Trade (Moderator: Friedrich Weigel, Berlin)*

15:45 Julian Jansen van Rensburg (Berlin), Alan Forrest (Edinburgh), What do we really know about the incense trade?*

16:10 Sterenn Le Maguer-Gillon (Paris), Incense Trade in the Islamic Period*

Part 5 *Integrating New Research Strands (Moderator: Michael C. A. Macdonald)*

16:45 Panel discussion*: Derek Kennet (Durham), Steffen Terp Laursen (Arhus), Kiersten Neumann (Chicago) Jérémie Schiettecatte (Paris)

Part 6 *Transregional Dimensions (Moderator: Martina Müller-Wiener, Berlin)*

19:00 Kiersten Neumann (Chicago), "Aššur, accept! Aššur, listen!": Connecting Arabia and Assyria through Incense and Olfaction

* Paper not published in this volume
** Presenting author

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A. Hausleiter & B. Huber (eds), *Scents of Arabia: Interdisciplinary Approaches to Ancient Olfactory Worlds*: 1–8. Bicester: Archaeopress.

New dimensions of interdisciplinary research on ancient scents and incense in Arabia

Arnulf Hausleiter and Barbara Huber

In the arid landscapes of ancient Arabia, the air was often filled with the rich, evocative scents of incense and spices, creating an invisible thread that connected diverse aspects of cultural practices. The story of these ancient aromas is not just a tale of fragrant substances but a multi-faceted journey into the heart of past Arabian societies. The scents of ancient Arabia were not merely olfactory pleasures, they were also powerful symbols embedded in the social, religious, and economic aspects of the time. Yet, despite their profound influence, the olfactory heritage of Arabia remains a largely untapped field of historical and cultural knowledge. This book aims to immerse readers into the current scientific debates regarding the aromatic world of ancient Arabia, exploring how scents shaped its history, economy, and identity.

The phenomenon of the 'incense road' has long symbolized the cultural interconnectedness of the Arabian Peninsula with its neighbouring regions. These trade routes were vibrant channels of commerce, transporting aromatics among other goods across vast deserts. The settlements and oases along these trade routes flourished, becoming dynamic centers of cultural exchange. Due to the economic significance of these goods, they have often been investigated through the framework of trade, primarily understood through texts from classical antiquity.

A cuneiform text discovered at the site of Sur Jur'eh (Iraq) on the Middle Euphrates in 1978 was a crucial element for advancing research on the trade of aromatic substances. It has become a key source for the perception and understanding of the caravan trade in 1st millennium BCE Western Asia (Cavigneaux & Khalil Ismail 1990; Frame 1995): This text, attributed to the local ruler Ninurta-kudurrī-uṣur, dubbing himself 'governor' of the land Suhu and Mari, reports the seizure of a trading caravan attempting to evade his taxation. For the first time, a pre-classical historical source, probably to be dated to the mid-8th century BCE, provided information on the composition of such a caravan. The text describes a caravan comprising 200 camels led by 100 men, and lists some of its cargo, including wool, *pappardilû* stones, and iron. Interestingly, any reference to South-Arabian commodities, such as aromatics or wood is missing from the text. This suggests that the caravan was 'in the middle of a trading cycle, or on its homeward journey' (Macdonald 1997: 340), perhaps returning from the city of Ashur, which, during the early 2nd millennium BCE, was renowned as a hub for textile trade within the Old Assyrian commercial networks with central Anatolia (Larsen 1976).

The actual tradesmen of this caravan attacked on the Middle Euphrates were 'people from Tema and Saba'. These toponyms point respectively to one of the most important oases of the Arabian Peninsula (the oasis of Taymāʾ) and to South Arabia (the land of Saba), the actual 'land of incense'. In addition to the booty, the governor, who apparently acted successfully between the Assyrian and Babylonian spheres of interest, describes the unstable political and economic situation he faced himself — exposed to attacks by 'marauders' from the desert (Cavigneaux & Ismail 1990; Frame 1995).

As far as the Middle Euphrates is concerned, there is now evidence for contacts and exchange with Arabia several centuries before the 8th century BCE; texts from the time of Tukultī-Ninurta II (911–883 BCE), and possibly earlier, indicate commercial activities aimed at trading exotic goods from the Arabian Peninsula through the desert, probably around the turn of the 1st millennium BCE (Bagg 2018). More recently, the scholarly view by

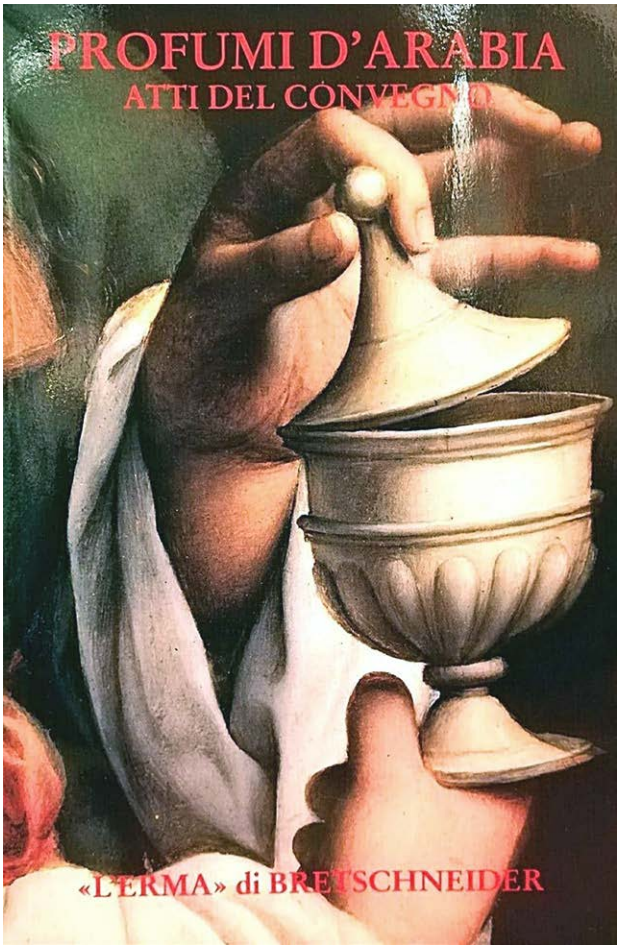

Figure 1. *Cover of the publication 'Profumi d'Arabia' edited by Alessandra Avanzini (1997)*

historians, on the Middle Euphrates area includes both sides of the river, i.e. the Syrian and the Arabian deserts (e.g. Masetti-Rouault 2023).[1]

A fundamental contribution in studying the 'Scents of Arabia' is the homonym publication *Profumi d'Arabia* edited by Alessandra Avanzini in 1997, published a quarter of a century ago (Fig. 1). This milestone of interdisciplinary research includes an unprecedented analysis of pre-modern sources, such as studies on itineraries, textual sources, vocabulary, anthropology, archaeological materials etc. by archaeologists, epigraphers, and historians. Until today, this publication is a unique collection of data relevant to the topic, although 'it is evident, that the papers dealing with commerce are the most numerous' (Avanzini 1997: 18). Several years later, the trade with aromatics was again the main objective of the book 'Food for the gods' edited by Peacock, Peacock and Williams (2007), focussing only on one particular period (the Roman period) of the long-lasting history of Arabian trade.

Recent advancements in the archaeological exploration on the Arabian Peninsula, in particular during the last 20 years, have, however, opened new research avenues (cf., anticipating, De Maigret 1998). These new approaches emphasize environmental investigations and the study of material evidence with interdisciplinary methods. This shift has led to an increased application of scientific analyses — such as pollen and isotope analyses, hydrology and biomolecular investigations of organic residues and sediments, which were used for reconstructing models of past climate and environments. Such analyses also enable the identification of ancient olfactory landscapes and the use of incense materials based on organic residues (see Huber et al. 2025). In addition, chronological horizons other than classical antiquity were also taken into consideration, such as the Islamic period (as Sterenn Le Maguer-Gillon emphasized in her contribution to the Special Session which is unfortunately not published in this volume; cf., Le Maguer 2016). This not only opened up a diachronic perspective, but her contribution, like those of the other speakers, went beyond presenting a mere inventory of the archaeological evidence explicitly addressing the use of scents. As a result, some of the paradigms established by earlier research could be overthrown — first and foremost, the mainly exogenic view on the cultures on the Arabian Peninsula. The latter has been fundamentally revised through a growing number of new research projects that offer more nuanced and locally grounded perspectives. At the same time, object studies combined with an ethnographic research methodology contributed to paving the way of a practice-oriented research perspective on this cultural phenomenon of intangible nature (Zimmerle 2021).

Of equal consequence in reshaping the perspective was the discovery of substantial Bronze Age occupation

[1] Cf. Liverani 1992, figs. 21-29 mapping the "economic geography" based on the annals of king Aššurnaṣirpal II on his military campaigns. Interestingly, incense is absent from the listed commodities.

in the major oases in north-west Arabia, contemporary to the large urban centres in neighbouring regions, such as Mesopotamia or Egypt (Hausleiter 2019; Luciani 2019). Based on these results, a new complex scenario of contacts and communication as well as the provision of raw materials and commodities arose, including the widening of the 'land of incense' going beyond South Arabia (Avanzini 1997: 16) to regions between (Eastern) Africa, Arabia and India (cf. Crowther et al. 2015). Consequently, the phenomenon of the exchange of olfactory substances at a larger historical and environmental scale can equally be considered 'an important step in proto-globalization' (Muthukumaran 2016: 271).

Archaeological excavations made a fundamental contribution to modifying the one-sided image of aromatics as a luxury item. While excavations at trading posts, such as at the Roman period port of Qanaʾ in Yemen (Sedov 2007) with a probable 'warehouse' for incense remain a rare exception,[2] investigations in the oasis of Taymāʾ revealed that particular scents were used in very different contexts: temples, domestic contexts, and cemeteries, thus suggesting that 'food for the gods' (cf. Peacock, Peacock & Williams 2007) may have constituted only one of several dimensions of the scents of Arabia. Importantly, trade may not have been the primary driver for the burning of scents and the creation of olfactory landscapes within these oases. Evidence suggests that locally available wood was among the oldest traces of materials used for olfactory purposes (Huber et al., this volume).

In fact, within the context of the new interdisciplinary research perspective on the archaeology of the north-western part of the Arabian Peninsula, the oasis of Taymāʾ plays a pivotal role. An unprecedented number of incense burners of various forms and materials have been excavated from different contexts at this multiperiod site, spanning a chronological range from the late 4th millennium BCE to late antiquity (Hausleiter & Eichmann 2018; Hausleiter 2019; Huber et al. 2018; Huber 2020). The first identification of certain pottery vessels as 'censers' at Taymāʾ is owed to Ḥ. I. Abū Duruk (1989: 15–16) when excavating the cemeteries of Sana'iye outside the walled settlement and thus drawing attention towards the firing of aromatics in other than 'luxury' contexts.

Figure 2. *The so-called 'al-Ḥamrāʾ Cube' with the representation of two incense burners (© DAI Orient Department, and Heritage Commission, I. Wagner)*

In Taymāʾ, the representation of burners and scents is also part of the iconography of paraphernalia recovered from religious contexts. From the two major excavated sanctuaries of 1st millennium BCE date, Qaṣr al-Ḥamrāʾ and Temple E-b1, different datasets regarding the reconstruction of the use of ancient scents in this oasis have been recovered: while in Temple E-b1 one sandstone burner was discovered, there is considerable iconographic evidence for incense burners in the context of ritual performances related to religious practices on both the 'al-Ḥamrāʾ Cube' and the 'al-Ḥamrāʾ Stele'.

On the former (Fig. 2), two incense burners with pointed corner elements ('crowns') are associated with ritual activities, including the depiction of a *bucranium* on an elevated platform, approached by a priest. To the left of the *bucranium*, a tall burner with an elongated, column-shaped base and a 'crown' where the incense is placed, is positioned on the first step of the *bucranium*'s platform.

[2] 'Its rooms were badly damaged by fire and a large amount of burnt incense was found all over its floors. The remnants of burnt incense were also discovered in baskets or big bags made of palm, which once stood in the corners of the rooms. These containers were used in ancient Hadramawt to carry and hold incense, which finds its correspondence with the modern practice' (Sedov 2007: 91; cf. ibid., fig. 4.6).

While the very base of this burner is not visible, its scale matches that of the priest, emphasizing its importance in the ritual. On the right side of the *bucranium* stands a larger, more detailed footed incense burner. Its central section is adorned with horizontal incised lines, and the upper part features again two pointed corner elements forming the crown. In the center of the crown the burning substance and fuel are visible, with smoke rising in a curve. The al-Ḥamrāʾ Stele shows a fragmentarily preserved representation of a similar burner. The inscription on the stele refers to the installation of the god Ṣalm (*Ṣlm rb/d*) in his shrine, but does not contain any detail on the connected performance or on the use of incense and/or incense burners (Norris in press). These depictions of incense burners in Qaṣr al-Ḥamrāʾ differ from the excavated contemporary specimens in the central part of the settlement, all of them consisting of a carved rectangular block. This may point to a different materiality of those burners which are depicted on the al-Ḥamrāʾ Cube and Stele, suggesting a material other than sandstone.

Only a few of the burners from Taymāʾ bear an inscription. A patronym, most probably indicating appurtenance or property, appears to be the rule, while the mention of the king, a god, or of the profession of the owner apparently occurs on an individual basis (see Macdonald 2020: 123, 125–127, 130). Equally, the curse on one of the Nabataean elaborate burners in the shape of a column indicates a specific value of this object for its owner. However, at Taymāʾ, none of the aromatic substances seems to have been mentioned on the burners, as in the case at Qaryat al-Faw oasis in southern central Arabia (e.g. Cotty & Robin 2010).

This publication is the result of the Special Session held at the 55th Seminar for Arabian Studies in Berlin in 2022. It aims to explore the transformative advancements that have reshaped the field through innovative methodologies. Positioned within the framework of the Seminar, the session sought to spotlight cutting-edge investigative techniques at the intersection of archaeology, molecular sciences, botany, art history, sensory studies, and ethnography.

Each discipline offers a distinct yet complementary perspective, collectively elucidating the significance of aromatic substances. Integrating their different perspectives is paramount, facilitating a holistic understanding that transcends the limitations of any single field. By synthesizing archaeological evidence with ethnographic insights, historical context, chemical analysis, and palaeoflora studies, we are able to obtain new insights into the practices and uses of Arabian scents. This interdisciplinary approach not only enhances the depth of study, but also provides a richer, more nuanced understanding of the role of scents, incense, and aromatic substances in ancient Arabian societies. Critical to this investigation is the identification of aromatic raw materials, their origins, and their distribution, as well as their diverse olfactory effects in various contexts. The previously dominant question of trade is re-examined from a global perspective, considering networks extending beyond Arabia, such as those reaching Assyria. This shift in focus moves from viewing scents solely as trade commodities and key elements in establishing extensive economic contacts to exploring the practical aspects of their use and the sensory impressions they created. Thus, the publication provides a comprehensive study of the complexity of aromatic substances and reveals their impact on rituals, daily life, consumption, and trade. The objective of this book is also to highlight and critically discuss recent research findings and methodological issues in the interdisciplinary study of the Arabian Peninsula. This includes challenges in identifying sample material, interpreting results in the context of other interdisciplinary investigations, and incorporating the 'archaeology of the senses' (Neumann & Thomason 2022, Hamilakis 2013), which examines the perception of scents burned. This collection of contributions also aims at bridging the gap between the past and our sensory experiences today. Through the lenses of the different disciplines, we delve into the world of ancient Arabian fragrances, uncovering their cultural significance, and their enduring legacy.

In the first contribution of the book, Kiersten Neumann (University of Chicago) provides a far-reaching overview of olfactory practices in Assyria and the connection to the Arabian incense trade, which was crucial in maintaining this cultural practice, ensuring that both the Assyrian king and the people could communicate with their deities through the power of scents. She explores how aromatic substances, sourced from mountains, forests, and desert landscapes, created an olfactory bridge to the divine, enhancing ritual practices. From the tenth to the seventh centuries

BCE, Assyria evolved into a vast empire. In the Assyrian capitals, aromatic substances and their potent aromas were integral to temple rituals, contributing to the purification and sensory environment. These substances included resins, wood shavings, and oils derived from a wide array of trees and plants, such as cedar, juniper, cypress, and myrrh. These aromatics, which were scarce in their heartland, necessitated their acquisition from distant regions, often sourced from southern Arabia, through trade and military campaigns, establishing a cultural perception of these materials as exotic and otherworldly. Archaeological evidence and textual sources from as early as the third millennium BCE attest to the use of incense and aromatics in various Mesopotamian contexts, with an increase in frequency and variety during Assyrian rule. The chapter also studies the crucial role of incense burners, highlighting their use in both temple and domestic contexts. Its olfactory significance extended beyond temples, permeating urban environments, gardens, royal audiences and banquets. By combining textual, archaeological, and visual evidence, Neumann's analysis illuminates the complex trade dynamics and cultural significance of aromatics, emphasizing their role in bridging the mortal and divine realms through powerful olfactory experiences and underscoring the geographical origins of these aromatics, detailing Assyria's expanding control over Arabian trade routes during the Neo-Assyrian period.

Sureshkumar Muthukumaran (National University of Singapore) explores the historical significance and distribution of bdellium, the aromatic oleo-gum resin produced by *Commiphora wightii*, a species found in both South Asia and south-eastern Arabia. This resin, valued for its pleasant scent and medicinal properties, was used in perfumery, medicine, and incense in past societies. This comprehensive reassessment examines the terminology associated with this plant in various ancient languages, with a focus on Akkadian sources from Mesopotamia, underscoring the importance of south-eastern Arabia (modern Oman) as a primary source of bdellium for ancient Afro-Eurasian communities. Muthukumaran's contribution criticizes previous identifications of the Akkadian word *guḫlu* with bdellium, proposing *bidurḫu* as the correct term based on linguistic and contextual evidence. The article discusses bdellium's presence in Mesopotamian records from the late 2nd millennium BCE and its significance in Assyrian and Babylonian contexts. Mid-7th century BCE letters reveal bdellium as part of a tribute from Dilmun (modern Bahrain), indicating its importance in the Persian Gulf trade network. He also highlights the earliest mention of bdellium in Vedic Sanskrit texts, where it was utilized as a protective charm and admired for its pleasant scent. Greek and Roman sources also note bdellium's origins in Arabia and India, reflecting its integration into ancient trade networks. This interdisciplinary analysis refines our understanding of bdellium's historical uses and sensorial impact, and at the same time highlighting the complex trade dynamics of the ancient world.

Elisabeth Dodinet's (University of South Brittany) contribution focusses on the plant raw materials and reviews the challenges and advancements in identifying ancient incense materials through chemical analyses applied to archaeological residues. Traditionally, the identification of incense relied on written sources, but these methods faced limitations due to the amorphous nature and frequent adulteration of incense materials. For these reasons, researchers have also turned to methods from the natural sciences, which allow for more precise determinations at the family or genus level, and occasionally at the species level. She discusses several plants that produce resins, particularly frankincense, derived from various *Boswellia* species, but also alternative incense sources, such as mastics coming from *Pistacia* trees as well as their origins and natural habitats. The chapter also emphasizes the need to re-evaluate the broad term 'incense', which historically included various materials beyond frankincense. These materials were chosen for their sensory properties and symbolic meaning, often linked to sacred landscapes and rituals. In conclusion, Dodinet calls for further research combining organic residue analyses with ethnobotanical studies to better understand the diverse botanical sources of ancient incenses and their cultural contexts. This multidisciplinary approach will help to clarify the historical use and trade of these aromatic substances, offering new insights into the rituals and economies of the past.

The following chapter by Barbara Huber et al. investigates the complex olfactory history of the ancient oasis of Taymāʾ, an important hub on the incense road. Utilizing metabolic profiling techniques, such as GC-MS and LC-MS/MS, the research team has unearthed the

biomolecular compositions of incense materials used at Taymāʾ over more than two millennia. This chapter is a testament to successful interdisciplinary research, blending archaeology, biochemistry, and palynology to illuminate the rich olfactory heritage of ancient Taymāʾ. The integrative approach of this study highlights the diversity of aromatic substances used in Taymāʾ beyond frankincense, including coniferous resins, plant oils, *Pistacia* tree resins, *Commiphora*-type resins as well as aromatic blends, and provides a detailed chronology of incense use in ancient North Arabia from the Middle Bronze Age to late antiquity. The findings reveal a clear chronological pattern: coniferous resins were prominent in the Bronze Age, *Pistacia* resins in the Early Iron Age, and frankincense became dominant from the second half of the first millennium BCE onwards. This shift reflects broader trade dynamics and/or evolving cultural preferences. In terms of spatial and functional patterns, *Commiphora*-type resins and scented mixtures are strongly associated with graveyards and funerary practices, and were not found elsewhere in the oasis. Moreover, the study underscores the economic role of Taymāʾ, highlighting it not only as a transit point but also as an active consumer of luxury goods, evidenced by the use of expensive frankincense in domestic settings.

William Gerard Zimmerle (New York University Abu Dhabi) explores the architectural and functional significance of portable, cube-shaped incense burners in the Arabian Peninsula, specifically in Oman's Dhofar region. Zimmerle's study integrates approaches from archaeology, ethnoarchaeology, and cultural heritage, emphasizing the continuity of incense burner production from the Bronze Age to the present. He meticulously traces the history and distribution of these burners, linking them to various periods and regions, including the Iron Age and Achaemenid Persian periods and highlights their widespread use in domestic, mortuary, and administrative-cultic contexts across the Arabian Peninsula. Furthermore, Zimmerle delves into the architectural features embedded in the design of these burners, suggesting that their production was influenced by the built environment and domestic architecture of the region. His ethnoarchaeological approach is particularly noteworthy, as it involves conducting interviews with contemporary Dhofari potters who continue to produce traditional incense burners. These interviews reveal a deep connection between ancient production techniques and modern craftsmanship, demonstrating the continuity of cultural practices. The potters' insights underscore the importance of traditional styles and the enduring influence of heritage in their work.

The work presented in this book not only sheds light on the olfactory heritage of Arabia but also opens up new avenues for future research and cross-disciplinary collaborations. The use of olfactory storytelling in museums and cultural heritage sites, as discussed in the concluding outlook by Sofia Collette Ehrich (University of Amsterdam), illustrates the potential for scents to enhance public engagement and historical understanding. By integrating olfactory experiences into exhibitions, heritage institutions can offer visitors a more immersive and memorable encounter with history. In her chapter, Ehrich also calls for a 'nose-on' approach, which suggests analysing archaeological contexts and objects from an olfactory perspective to uncover unique insights. This method reveals aspects of Arabian history that might be missed through traditional visual analyses. She outlines the potential for Arabian archaeology to significantly contribute to Smell Culture Studies due to its rich archaeological record, interdisciplinary research practices, and use of technologies from archaeological sciences. Ehrich envisions a future where Smell Culture Studies, which are currently mainly focused on Europe, expand to include diverse cultures, advocating for cross-disciplinary collaborations that enhance the representation of global olfactory heritage.

This collection presents an exploration of scent as an emergent field within archaeological research, underscoring its value in reconstructing cultural practices and identities in ancient Arabia. Traditionally overshadowed by visual and textual analysis, scent is revealed here as a deeply integral element of human experience, linking memory, emotion, and identity through the direct pathway of olfaction to the brain's limbic system. By establishing scent as a viable research domain within archaeology, this volume affirms the significance of fragrances not just as byproducts of ritual or luxury, but as active cultural agents that shaped societies, practices and economies in Arabia and beyond. Thus, in addition to the increasingly detailed recording of scientific data, the further exploration of the sensual dimensions of the ancient olfactory worlds and their social contexts has been identified as a future research aim.

The present volume positions ancient Arabian olfactory traditions within the framework of Intangible Cultural Heritage, a category that preserves the transient yet powerful expressions of culture beyond the material record. Through this lens, the authors demonstrate that olfactory heritage is just as critical to understanding ancient societies as physical monuments or artifacts. The contributions add new layers to our understanding of how past societies integrated scent into their spiritual, social, and domestic lives. By studying ancient smells, the collection reframes scent as a cultural hallmark, highlighting its value as a legacy to be preserved and to be recognized alongside more tangible heritage. Furthermore, the enduring legacy of Arabian olfactory traditions has been traced, resonating through time into modern perfumery and cultural practices. The Dhofari potters continue to produce incense burners similar to those of ancient times, highlighting the continuity of olfactory-related craftsmanship in Arabian culture. These burners, which served both domestic and ritual functions in the past, remain central to social life today, bridging historical traditions with modern practices and preserving intangible heritage through daily use. At the same time, the modern harvesting techniques, production and distribution methods for frankincense in Oman, as investigated in the paper presented by Abdulrahman Mahad Al Maashani at the Seminar (who unfortunately, was unable to publish in this volume), reflect millennia-old traditions of sourcing and valorizing this precious raw material.

By anchoring the scents of Arabia within archaeology, intangible heritage, and modern practice, this volume advocates for an expanded view of cultural heritage. It proposes that the sensory experiences of the past — especially those of scent — are essential to a comprehensive understanding of human history, challenging us to engage with the past through our noses as well as our eyes.

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‘Aššur, accept! Aššur, listen!’ Connecting Arabia and Assyria through aromatics and olfaction

Kiersten Neumann

Summary
The abundance of written sources, visual imagery, and archaeological material related to the burning of incense attests to the central role of olfactory practices in Assyria during the Neo-Assyrian period (934–612 BCE), particularly in the context of communicating with and caring for divinity. Aromatic substances—sourced from the trees and plants of mountains, forests, and desert landscapes—and the scents they produced when burnt served as an “olfactory bridge,” connecting the earthly realm to the divine. Assyria’s connections to the Arabian incense trade were instrumental in shaping and sustaining this cultural understanding of aromatics. By fostering trade relations with and, at times, exerting imperial control over the people of Arabia, the Assyrian state secured not only economic and territorial gains but also the necessary resources for its king, court, and populace to communicate with their gods. This chapter examines the sensory dimensions of incense in Assyria, beginning with a consideration of the raw materials and types of incense burners used in olfactory practice. It then delves into the geographical origins, trade networks, and tribute systems associated with this highly valued commodity, with a particular focus on Arabia. Finally, it considers the otherwordly conceptions of incense in an Assyrian context of practice, revealing its broader significance in bridging the human and divine.

Keywords: Assyria, Arabia, incense, olfaction, sensory experience, ritualized practice, trade, tribute

Introduction

Raw materials that held the greatest value in the context of ritualized practice in Assyria were ones that exuded brilliance and shine, vibrant colours, contrasting tones, robust size and strength, engaging textures, and powerful aromas. Extraordinary origins added further value. Aromatic substances — e.g., cedar shavings or frankincense resin — were effective and potent as ritualizing agents not simply because of the ephemeral olfactory and visual sensations they produced when burnt, but also because of the distant, foreign, and seemingly inhospitably lands from which they were acquired — a quality that, within an Assyrian context of practice, imbued them with a sense of the exotic and otherwordly. Whether sourced from the trees or plants of mountains, forests, or desert landscapes, aromatic substances and the aromas they produced when burnt created an olfactory bridge to the gods of Assyria, transposing ritualized practice beyond the earthly realm. Assyria’s connections to the Arabian incense trade helped establish and thereafter uphold this cultural understanding of aromatics. In fostering trade relations with — and at times imposing a level of imperial control over the people of — Arabia, the Assyrian state ensured not only economic and imperial gains but also the continued ability for its king and court, as well as the people of Assyria, to communicate with their gods.

The state of Assyria

From the tenth through the seventh centuries BCE, the state of Assyria grew into an empire that dominated from present-day Iran to Egypt before falling rapidly to the combined forces of Babylonians and Medes. This was the last stage of a process that can be traced back to the mid-third millennium and the growth of the old trading city and cult centre of Aššur on the Tigris river in northern Mesopotamia. By the fourteenth century, a succession of able rulers established a strong Middle Assyrian kingdom, gaining independence from the kingdom of Mitanni. A successful policy of territorial expansion and administration brought stability and wealth to Assyria

during the Neo-Assyrian Empire of the first millennium. An abundance of information about this empire has been preserved in the extensive archaeological remains of its capital cities, smaller towns, and provincial centres. In addition to artistic traditions, literary materials written in Akkadian — the official language of the Neo-Assyrian court written using the cuneiform script and preserved on clay and stone — reflect the centuries of innovations that helped create a distinct Assyrian cultural identity.[1]

Assyria was named after the city Aššur and the god of the same name, who became the supreme deity of the emergent state and later the empire. Under Neo-Assyrian kings, the administrative capital shifted from Aššur to Kalḫu (modern Nimrud), then Dur-Šarrukin (modern Khorsabad), and finally Nineveh (modern Mosul including the mounds Kuyunjik and Nebi Yunus), though past capitals remained important for reasons of continuity and their resident divinities. As divinely sanctioned ruler and high-priest of the god Aššur, the responsibility for the construction and maintenance of the cities and their temples fell to the king; he similarly played an important role in temple proceedings accompanied by members of the royal court and select temple personnel, some of whom filled in for him when necessary.[2] Aromatic substances and olfaction were integral to these performances, contributing to the overall sensescape of the temple: fumigation offered a means of cleansing and purification, while the smells from incense burners and scented oil offerings nourished the gods. Yet olfaction's import was not limited to the temple, its potent aromas and cultural significance marking the performative environment of urban and extra-urban practices throughout Assyria and beyond.

Raw materials

Archaeological and textual evidence dating as far back as the third millennium BCE attests to the burning of incense and aromatics in various forms and contexts throughout Mesopotamia;[3] this continues to appear — with increasing frequency, opportunity, and variety — in sources of the first millennium BCE, especially during the period of Assyrian imperial rule. Archaeological materials include most notably incense burners themselves but also related visual imagery on relief carvings, vessels, and wall paintings, for example. Written references appear understandably in ritual texts, but also in several other genres (e.g., royal and votive inscriptions; medical, literary, and mythological texts; and administrative and economic documents and correspondence). These sources speak to the contexts within which aromatics were burnt, the types of aromatic substances that were burnt, and the sourcing of such substances.

Akkadian texts employ a multitude of terms to refer to the substances that emitted aromas when burnt. Broad terms include *ḫibištu* ('cuttings of resinous and aromatic substances'); *kisittu* ('wood shavings [of aromatic woods]'); *qutāru* ('fumigant'); *qutrīnu/qutrinnu/qutrēnu* ('incense'); *riqqu/rīqu* ('aromatic plant'); *siltu* ('shaving, splinter'); *za'u*, *ḫīlu*, and *dāmu* ('resin'); and *ziqpu* ('shoot [of a tree or other plant]').[4] Incense could take the form of sweet-smelling resins — the hardened form of liquid gum obtained through an incision made into the bark of a tree — wood shavings, and oils. These substances were obtained from coniferous timbers, myrrh, and frankincense that were sourced from a wide geographical area surrounding Assyria. Among the types of trees and plants were cedar (*erēnu*), juniper (*burāšu*

[1] On the history of Assyria, see Postgate 1992b; Radner 2011; Frahm 2023. Select publications resulting from excavations of Assyrian capital and administrative cities include Place 1867–1870; Layard 1849; Layard 1853; Loud 1936; Loud & Altman 1938; Mallowan 1966; Oates & Oates 2001. For artistic and literary traditions, see Curtis & Reade 1995; Bahrani 2017; Grayson 1991; 1996; volumes from the Royal Inscriptions of the Neo-Assyrian Period project; and volumes from the State Archives of Assyria series.

[2] On connections between the Assyrian court, king, and temple practice, see Neumann 2019b; 2019a; and on the use of incense in these contexts, Neumann, forthcoming. On religion and ideology in Assyria, see Pongratz-Leisten 2015.

[3] In its broadest usage, ancient Mesopotamia includes all of present-day Iraq, as well as parts of Syria, Turkey, and Iran. Here, from the fourth millennium BCE onwards small villages grew into large cities, city-states, and eventually empires, with influence and connections expanding by way of trade and migration across ancient West Asia and beyond. From the earliest evidence of settlement and hereinafter, this region was home to different groups of people – including the Sumerians, Akkadians, Babylonians, and Assyrians – each demonstrating cultural, religious, social, administrative, and political traditions and practices that were both distinguishable and in common.

[4] For Akkadian terms, see the respective entries in the Chicago Assyrian Dictionary (CAD) for definitions and references (Oppenheim 1956–2010).

and *duprānu*), cypress (*šurmēnu*), acacia (*ašāgu*), and tamarisk (*bīnu*); these would have been predominantly sourced to the west. The suggested translations of *murru* as 'myrrh' (specifically *Balsamodendron* or *Commiphora myrrh*), *labānatu* as 'frankincense' (*Boswellia sacra*), and *budulḫu/bidurḫu* as 'bdellium' (*Commiphora wightii*) speaks to connections with southern Arabia.[5] I return to the topic of geographical regions below.

Texts from Assyria tell of the filling of incense burners with charcoal (*pēntu/pēmtu*) before aromatics were added in order to facilitate smoldering over a long period of time. Verbs of action used to describe the burning of incense include *sarāqu* ('to strew, scatter, sprinkle') and *qatāru* ('to rise [said of smoke]'), in the D-stem, *qutturu* ('to cause something to smoke, to make an incense offering, to cense, to fumigate, to fume incense'), and *ḫâbu* ('to purify by fumigation'). A passage from the ritual instructions of the Assyrian diviner (*bārû*) uses this last verb when describing the burning of cedar for the gods: 'I burn as incense for you pure cedar, bundles of shavings(?) (with) sweet-smelling resin (and) bundles of pure cedarwood, beloved of the great gods' (Zimmern 1901: nos 75–78, r. i 57).

The raw materials from these aromatic trees and plants were also processed to create fragrant oils that could be used for burning and general applications beyond ritualized practice. Perfume recipes preserved on second-millennium BCE clay tablets from Assyria, the birthplace of maceration and *enfleurage* (the extraction of a plant's essential oils and binding them with an organic solvent to stop evaporation), offer unique insight into the material, procedural, social, and economic aspects of this aromatics industry (Ebeling 1950; Escobar 2012; Joannès 2013; Cousin 2016). Notably, one such recipe — preserved on a tablet from Aššur — lists myrrh (*murru*) among the required raw materials. In these texts, expressions such as 'oil of cedar' and 'oil of juniper' refer to oil *with* cedar or juniper aroma, i.e., perfumed oils. Assyrian texts also record the use of aromatic substances for medicinal purposes: for example, in a letter to the king offering remedies for a nosebleed, the chief physician prescribes the following: 'They crush it, mix it with cedar resin, wrap (the mixture) in red wool, and recite an incantation over it and insert (the tampons) in the nostrils' (Parpola 1993: no. 321, 13–17).

Incense burners and olfactory practice

Textual sources provide an illuminating introduction to the specialized furnishing that was used for long-burning, sweet-smelling resins and wood shavings in Assyrian olfactory practices. Akkadian texts preserve terminology for different types of incense burners: *nignakku* and *ša tēlilti* refer to smaller, portable censers, the latter used specifically for purifying by way of fumigation; *šēḫtu* designates tall, stationary incense burners; and *kinūnu* signifies braziers. These furnishings were manufactured from several materials, including stone, clay, and precious and semi-precious metals (gold, silver, and copper or bronze). While the archaeological record has preserved stone and clay examples, textual sources attest to those made of precious materials. For example, a votive inscription of king Aššurbanipal (reign 669–631 BCE) tells of a gold incense burner that he gifted to the god Marduk (Novotny & Jeffers 2018: Ashurbanipal 225, r. 1′–6′). Drawing on these textual sources alongside archaeological evidence and imagery, I have argued for a tripartite classification system for Assyrian incense burners: tall circular incense burners with tapered stands, short circular burners, and cubic burners. Here, I review the forms and styles of these types by way of highlights from the archaeological and visual records.[6]

A well-articulated tall circular incense burner appears in a series of stone wall panels (orthostats) showing a lion-hunt sequence carved in low-relief from the North Palace of Aššurbanipal at Nineveh. The scene shows the king pouring a libation on the bodies of slain lions; to the left of the lions stand offering accoutrements, including a table with lion-paw legs that is laden with offerings and a tall burner with conical top

[5] On the correlations between Akkadian terms and known species of trees and plants, which is based on textual descriptions, archaeological evidence, and studies of regional resources, see Thompson 1949; Postgate 1992a; Potts et al. 1996; Bagg 2006; Zimmerle 2014; Middeke-Conlin 2014; Muthukumaran, this volume; and the respective entries in the CAD (Oppenheim 1956–2010). While *guhlu* has commonly been understood as 'mukal myrrh' and 'bdellium' (*Commiphora mukul*, syn. *Commiphora wightii*), suggesting an additional link between Akkadian texts and the aromatic woods of south-eastern Arabia, Sureshkumar Muthukumaran (in his contribution to the present volume) argues for an alternate understanding of *guhlu* as kohl — the 'fine paste used for eye make-up and its chemical constituents.'

[6] For a full discussion, see Neumann 2023b. On censers of the third and second millennia BCE in Mesopotamia, see Pieńkowska 2018.

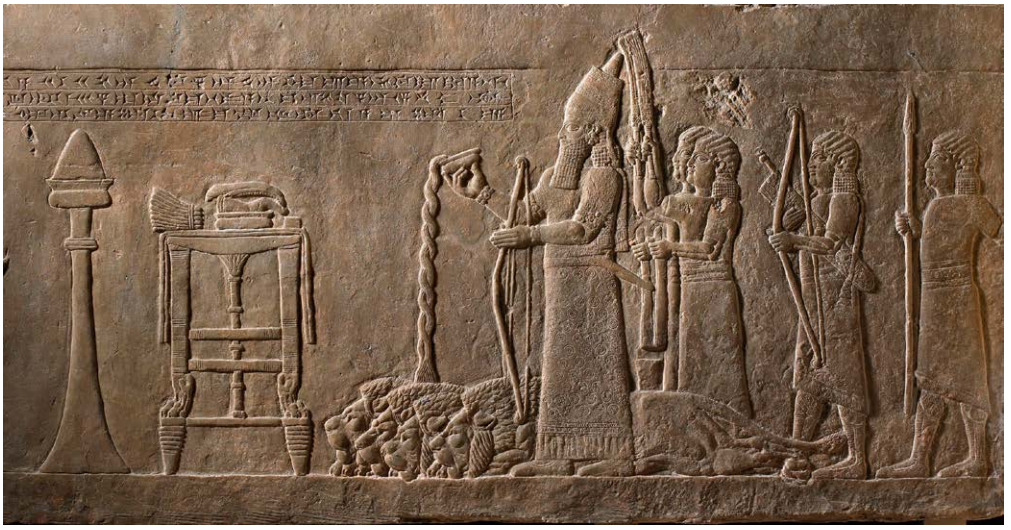

Figure 1. *Relief panel showing an offering scene with an incense burner. Gypsum. Iraq, Nineveh, North Palace. Neo-Assyrian period, reign of Aššurbanipal (645–640 BCE). British Museum, BM 124886. © The Trustees of the British Museum.*

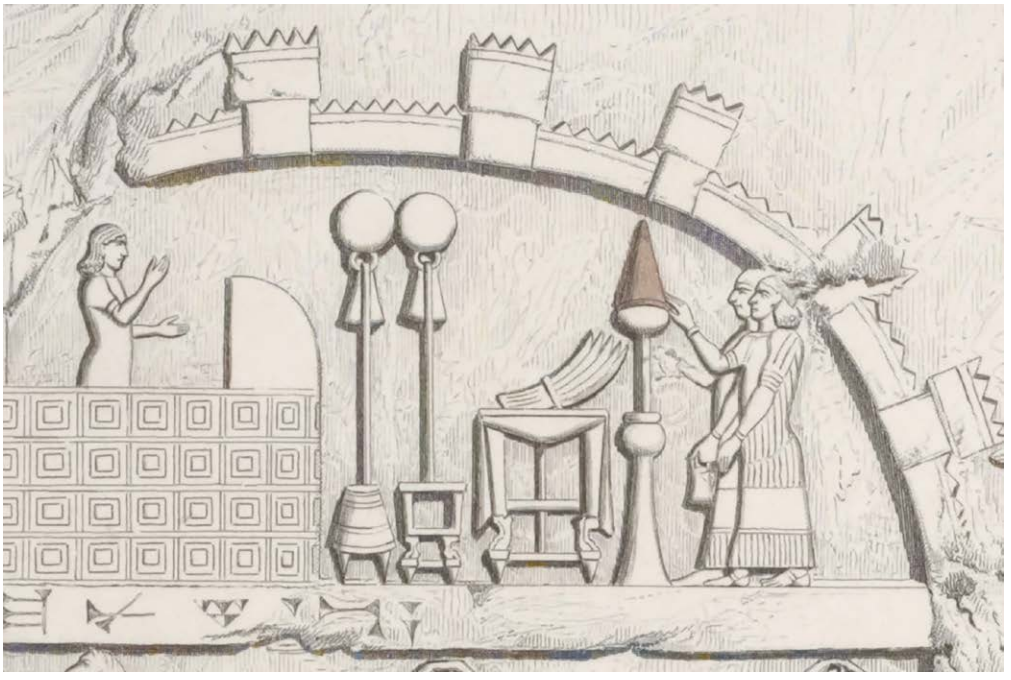

Figure 2. *Drawing of relief panel from Sargon II's palace at Dur-Šarrukin. After Botta and Flandin 1849–1850, II, pl. 146.*

(Fig. 1). Interestingly, nineteenth-century excavators at Dur-Šarrukin observed red paint preserved on the top of a tall incense burner rendered in a relief panel from the palace of Sargon II (reign 721–705 BCE), a colour indicative of the heat of the cover caused by the burning incense within (Fig. 2). The early twentieth-century excavations of Aššur by the Deutsche Orient-Gesellschaft, under the direction of Walter Andrae, uncovered two glazed ceramic vessels with surface imagery that shows this same style of incense burner within offering scenes, here shown with rising flames (Andrae 1923: pls 23, 25, 26, 29) (Fig. 3). The Iraq Antiquities Department's mid-twentieth century excavations of the temple of the Sibitti at Dur-Šarrukin uncovered the most well-preserved archaeological example of this type: three tall circular stone burners (The one complete example was housed at the Mosul Museum, though it was partly destroyed by ISIS in 2015; fragments of the other two remain on-

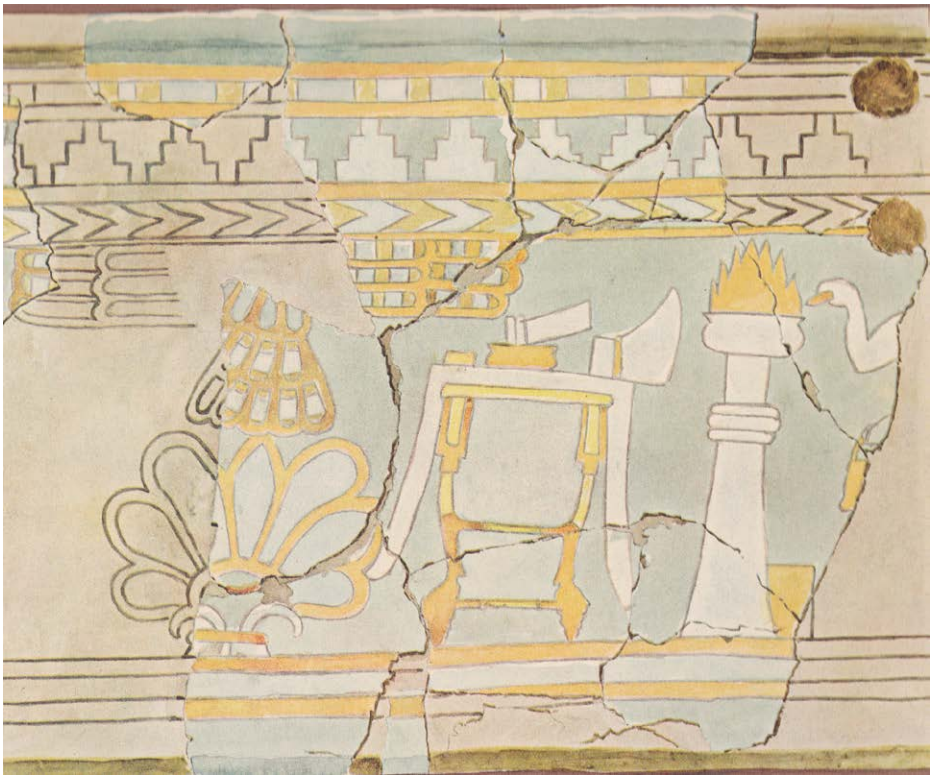

Figure 3. *Watercolor of a glazed vessel from Aššur. Vorderasiatisches Museum, Berlin (VA 5043). After Andrae 1925: pl. 29.*

Figure 4. *Tall circular stone incense burners. Iraq, Dur-Šarrukin (Khorsabad), Sibitti temple. Neo-Assyrian period, reign of Sargon II (r. 721–705 BCE). (right photo by Stephen Batiuk).*

site. Safar 1957; Brusasco 2016: 235–236, fig. 25; al-Obeidi & Thomas 2023: 80) (Fig. 4). As these examples suggest, this type of burner was closely associated with the presentation of offerings to the gods.

Short circular incense burners — similarly attested both in relief panels and as three-dimensional archaeological finds — consist of an integral bowl, broad base, and modest to more elaborate decoration

Figure 5. *Short circular incense burner. Basalt. Iraq, Guzana (Tell Halaf), temple. Aramaean–Neo-Assyrian period (9th century BCE). Vorderasiatisches Museum (VA 12793). © Staatliche Museen zu Berlin – Vorderasiatisches Museum / Olaf M. Teßmer.*

Figure 6. *Incense burner with mythological figures carved in relief. Stone. Iraq, Nineveh. Neo-Assyrian period (8th–6th century BCE). British Museum (BM 1930-5-8, 218). © The Trustees of the British Museum.*

such as molding, drooping petals, and fluted shafts. Such qualities are well-preserved on an example from a temple at Guzana (modern Tell Halaf), the capital of an Aramaean state that was incorporated into the Neo-Assyrian Empire at the end of the ninth century BCE (Fig. 5). This second type is attested in varied contexts, showing up in divine environments — as is the case for the Guzana burner and also another from the Nabu temple at Kalḫu that preserves traces of burning (Searight, Reade & Finkel 2008: 88, no. 582, fig. 56 [BM 1994-11-5, 30]) — and royal contexts, including the elaborate garden scene from the relief panels of Aššurbanipal's North Palace. Represented in the latter, between the supine king and enthroned queen, is a laden offering table and to their sides a pair of short incense burners: shown with covers, these burners were likely crafted of metal and appear to have fluted circular shafts with decorative rings and molding (Aruz, Graff & Rakic 2014: 73–74, no. 22 [BM 124922]).

Housed at the British Museum is one of the most well-known Assyrian cubic incense burners, i.e., the third type (Fig. 6). This limestone example from the temple of Ištar at Nineveh, standing 41.5 cm tall, has three-stepped crenellation design on the top and relief carving on its vertical faces; the top surface with integral bowl has a black mark from burning as well as

Figure 7. *Cuboid-shaped incense burner. Baked clay. Iraq, Nippur (Nuffar). Neo-Babylonian period (7th–6th centuries BCE). Penn Museum, B15520. © Penn Museum.*

a reddened area from heat (Searight, Reade & Finkel 2008: 89–90, no. 585, fig. 57). Like the second type, cubic burners show up in diverse contexts, including temple doorways, gardens, and mountain ranges. This form likely also brings to mind the small cuboid-shaped, portable incense burners with four stout legs (both plain and with decorative patterns) attested from the third through the first millennium BCE throughout Western Asia — from the Arabian Peninsula to the Upper Euphrates and the Levant, including southern and central first-millennium Mesopotamian sites in contexts that suggest a primarily domestic use (e.g., Babylon, Nippur, Ur, and Uruk) (Fig. 7). William Zimmerle's scholarship has connected such cuboid burners to the widespread trade, overland and maritime, of Arabian aromatics (2014; 2021). Yet despite the integral involvement of Neo-Assyrian rulers in the Arabian aromatics trade, discussed further below, cuboid burners of this exact type have not been found in Assyria to date. Overlap does occur, however, in Babylonian and later Achaemenid practices with the use of Assyrian-style tall circular incense burners for activities associated with the temple and divinity. Dated to the Late Babylonian-Achaemenid temporal divide (end-of-sixth–early fifth century BCE), for example, is an eyed-sardonyx cylinder seal with a double scene of combat and ritualized practice, the latter consisting of a worshipper standing before a tall circular censer with a rounded conical cover (BM 89324). A text of the Neo-Babylonian king Nabonidus (reign 556–539 BCE) commemorating his rebuilding of Emašdari ('House of Animal Offerings'), the temple of the goddess Ištar of Agade, reaffirms the importance of such olfactory practices for temple maintenance and caring for divinity: as testament to the prior ruined state of the temple, the king cites the lapse in incense-offerings.[7]

Worth noting are a few additional archaeological finds from Assyrian temples that suggest alternate forms of burning incense beyond the standard incense burner. Several stone statues of divine attendants recovered from temple doorways, for example, have trays on their heads or in their outstretched arms — these trays may have been used to contain burning aromatics directly or to support vessels containing burning aromatics.[8] Stone offering tables, which are well-attested for Assyria (see Fig. 4, far left), likely served a similar function: one example was excavated at the entrance to the Ninurta temple at Kalḫu, seemingly repurposed as an incense burner.[9] The placement of such objects with the potential of emitting scents at doorways affirms olfaction was also used to mark external boundaries of temples.

Textual sources notably expand on the connection between the burning of incense and practices involving divinity and the otherwordly in Assyria. A letter from a priest to the Assyrian king regarding the restoration work of Esagil, the temple of Marduk in Babylon, denotes the importance of aromatics in the laying of foundations: 'Concerning the aromatics, sweet-scented oil, red earth paste and precious stones, which we are to lay in the

[7] The inscription is preserved on four clay cylinders that were excavated at Babylon in the Emašdari temple, three of which were found in situ in its brick structure (Weiershäuser & Novotny 2020: Nabonidus 2, i 33–ii 9).

[8] For statues from Dur-Šarrukin, see Place 1867–1870, I: 122–126; Loud 1936: 98–99, 107, figs 111, 112, 107, 108 and 59, pls 17, 45, 47; and from Kalḫu, Mallowan 1966, I: 260–263, fig. 243; and for both, Neumann 2023: fig. 8A–D.

[9] On the example from Kalḫu, see Reade 2002: 170–171, figs 6, 32; Neumann 2023b: fig. 8D (BM 118806); and on Assyrian offering tables in general, including those from Dur-Šarrukin, see Neumann 2019b; 2023a; al-Obeidi & Thomas 2023: 78–79.

foundations, let the king, my lord, issue an order for them to give (them) to us' (Cole, Machinist & Parpola 1998: no. 161, r. 7–10). Ritual instructions for laying foundations — of temples and private houses — similarly prescribe aromatics, and specifically burners burning resins and oils, to be placed on the ground before foundation deposits and the first bricks.[10] The same is true for instructions related to the interment of foundation figurines, whose function was to ward off evil for private, royal, and divine residences alike (Wiggermann 1992; Schmitt 2004; Neumann 2019a).

Notwithstanding, aromatics were arguably most crucial during the presentation of offerings to the gods. First, all participants, furnishings, and offerings themselves had to be properly purified. Textual sources from the Neo-Babylonian period are particularly enlightening in this respect, harping on the cleanliness of temple personnel and in particular the priesthood, who were required to undergo a rigorous process of purifying their bodies and dress — steps that would have included purification by way of aromatics — in order to achieve the state of ritual purity required in order to serve divinity: 'the initiate now reaches the stage of ritual purity: he can contact the deity orally (purity of the mouth), perform ritual acts (purity of the hands) and walk around in the temple without endangering its cultic purity (purity of the feet)'.'[11] A ritual text for the royal presentation of offerings in the Aššur temple during a festival affirms the importance of purifying the ritual space (Parpola 2017: no. 1, 14–18):

> He swings the incense burner of purification (*ša tēlissi*) over the table, saying: 'The hand is released.'
> He swings it in the centre of the house, saying 'The centre of the house is released.'
> He swings it in the area of the incense burners (*šēḫtu*), saying 'The house is seized.'
> He swings it over the incense burner (*šēḫtu*), saying: 'May Fire purify.'
> He gives incense thrice, saying: 'Aššur, accept! Aššur, listen.'

In the temple, offerings and related furnishings were placed directly in front of the dais, upon which stood the divine image. A ritual text on offerings to be made to the god Nusku by the Middle Assyrian king Tukulti Ninurta I (reign ca. 1243–1207 BCE) stands as example; following are the lines from the text involving aromatics (Parpola 2017: no. 27, 1–6, 46', r. 1, r. 7):

> (1–6) Tukulti-Ninurta (I), king of Assyria, performed and instituted the (following) rites for Nusku: When you are to perform a sheep offering to Nusku, you go to the house of Sîn (and) let sunshine enter it through its doorway. You set up a chair beside the house under the god, lay clean red wool upon it, and place a bowl of sweet oil (*šamnu ṭābu*), aromatics (*riqqu*), *burāšu*-juniper, and tufts of red wool upon it. You set up a table before Šamaš, light an incense burner (*šēḫtu*), and place it behind the table. You place two libation vessels (and) two libation bowls to the left of the burner (*šēḫtu*), and place a container of brushwood behind the burner (*šēḫtu*).
>
> (46') Ea sets off (in procession). You carry a portable incense burner (*nignakku*) (loaded) with *burāšu*-juniper fragrance before him ... (and) sing, '.....'
>
> (r. 1) You light a burner (*šēḫtu*), pour oil into the container, place ... before the bed (and) before [DN].
>
> (r. 7) You offer fatty tissue and roast meat before Šamaš, make a flour/incense-offering, pour oil, honey and beer...

The importance of incense's potent aroma, suggested by images of burners with flames and smoky emissions, is also professed in written sources. An inscription of king Esarhaddon (reign 681–669 BCE), for example, articulates both incense's aroma and its distant origins: 'I piled up before them (the gods) the harvest of the sea (and) the abundance of the mountains. The burning of incense, a fragrance of sweet resin, covered the wide heavens like a heavy fog' (Leichty 2011: Esarhaddon 57, vii 2–8). A line from an explanatory text attributed to Kiṣir-Aššur, a ritual expert (*āšipu*) of the Aššur temple, attests to both the divine associations and purification abilities of

[10] Ambos 2004: 117–125 (II.A.2.1, 20, 23; *Enūma IM.DÙ.A tappatiqu*, 'When you lay the foundations [of the house of a god]'); see also, 155–166 (II.C.2. *Ṭuppi ḫišiḫti uššē bīt ili epēšu enūma uššē bīt ili tanamd*, 'Tablet for the materials needed in order to lay the foundations of a house of a god: When you are laying the foundations of a house of a god'); see further, Neumann 2019a.

[11] Löhnert 2010: 191, quoted in Waerzeggers 2011: 66. For a recent consideration of purity in Assyro-Babylonian procedures, see Borrelli & Escobar 2022.

Figure 8. *Relief panel showing a garden with an incense burner. Gypsum. Iraq, Nineveh, North Palace. Neo-Assyrian period, reign of Aššurbanipal (ca. 645–635 BCE). British Museum, BM 124939,a. © The Trustees of the British Museum.*

aromatic smoke: 'The cedar (resin) (*erēnu*) which they burn in front them is the loose flesh of the evil gods; they smelled the scent and went into hiding' (Livingstone 1989: no. 39, r. 24–25). The combination of the verb *eṣēnu*, 'to smell (an odor)', with *qutrinnu*, 'incense', is also used to describe the gods smelling and inhaling incense. What is more, as the excerpts above relay, the presentation of offerings also included recitations and prayers, foodstuffs and libations, and at times musical performances, which altogether would have created a truly dynamic and multisensory experience — a mingling of the visual, auditory, kinesthetic, and perception of time.

Assyrian practices independent of temples also depended on incense's olfactory phenomena, whether offerings made out in the open (e.g., in military camps or at rivers and lakes) or acts of divination, medicine, and childbirth, in addition to purifying building foundations and cleansing a house of evil, as discussed above. Akkadian ritual texts such as *namburbi*, *šurpu*, *qutāru*, and *maqlû* frequently cite fumigation and olfactory offerings as components of practice, sometimes with specific types of incense being associated with a particular ailment or desired outcome.[12] Royal audiences and banquets also included the burning of incense, the aroma mingling with that of food and drink and other sensorial phenomena (e.g., Parpola 2017: no. 33). Here, incense would have provided a means of purification and of offering, the Assyrian king understood as a divinely sanctioned ruler occupying a place between the mortal and divine realms. Yet the presence of incense would also have bolstered his political standing — a tangible and visible demonstration of his ability to source prestigious commodities.

Representations of incense burners in royal gardens and parks suggest comparable affiliations with the

[12] *namburbi* ('[rituals for] undoing of it') provide instructions for averting evil foretold by omens (Maul 1994); *šurpu* ('burning') offer instructions for absolving patients of a curse resulting from a broken oath (Reiner 1958; Simons 2017); *qutāru* ('fumigation') is a medical-fumigation series of texts (Finkel 1991); and *maqlû* ('burning') is a lengthy anti-witchcraft ritual (Abusch 2015). On incantation series in general, see Mirelman 2018.

burning of incense, gardens similarly being truly multisensory spaces and often shown incorporating an element of the royal sphere and the divine. A scene from the relief panels of the North Palace of Aššurbanipal, for example, shows a cubic incense burner standing on a path in a park replete with trees, canals fed from an aqueduct, and a columned building with a royal stele (Fig. 8). What is more, the very existence of such gardens was a declaration of the success of the king. Much like the sourcing of incense, gardens and parks materialized his success in obtaining through interregional travel and trade foreign and exotic species of plants for the Assyrian heartland. This sentiment is captured by the so-called Banquet Stele of Aššurnaṣirpal II (reign 883–859 BCE). The text inscribed on its surface records the species of trees and plants the king brought back from campaigns in the highlands in order to populate his royal orchards in Assyria: the fragrance from such fruit and gum-producing trees is said to have pervaded the gardens' walkways (Grayson 1991: Ashurnasirpal II A 0.101.30; see also Wiseman 1952).[13]

Geographical origins, trade, and tribute

Textual sources from the Neo-Assyrian period document specific geographical regions from which aromatic trees and plants were acquired. Regions west of the Euphrates and stretching into Anatolia included Mount Amanus ('Cedar Forest'), Mount Lebanon, and Mount Hermon. Aššurnaṣirpal II states in a royal inscription, 'I marched to Mount Lebanon (and) cut down beams of cedar (*erēnu*), cypress (*šurmēnu*), (and) *duprānu*-juniper' (Grayson 1996: A.0.101.50, 25–31). Sargon II's royal inscriptions similarly speak to trees originating to the west, remarking on their olfactory abilities: 'boxwood (*taskarinnu*), cedar (*erēnu*), cypress (*šurmēnu*), (and) every kind aromatic (*riqqu*), the products of Mount Amanus, whose scent(s) are pleasant' (Frame 2021: Sargon II 7, 142–143). The same king's eighth campaign against the land of Urarṭu to the north-east of Assyria provided access to the Zagros Mountains. In a letter written in the first-person to the god Aššur, the king describes the mountainous landscape, giving insight into the Assyrian conception of such terrain — a point I return to in the next section (Frame 2021: Sargon II 65, 13–19):

> With the great support of the gods Aššur, Šamaš, Nabû, (and) Marduk, I directed the march into the mountains for a third time. I turned the chariot(s) (lit.: 'pointed the yoke') of the gods Nergal (and) Adad, (whose) standards go before me, towards the lands Zikirtu and Andia. I advanced in between Mount Nikippa (and) Mount Upâ, high mountains that are thickly covered with all kinds of trees, among which (one becomes completely) confused (as to direction), whose very entry is terrifying, (and) over whose (whole) environs, just as in a cedar forest, a shadow is cast with the result that the one who takes the road through them sees no sunlight... Mount Simirria is a great mountain peak that points upward like the blade of a spear and who(se) top is higher than the mountains where the goddess Bēlet-ilī dwells. Its summit touches the sky above, and its roots are made to reach down below into the netherworld.

Assyria also had connections further eastward toward the Indus Valley (Meluhha in the textual sources). Yet remarkable for Assyria's imperial period is the intensification of connections with the Arabian aromatics trade. With the increasing use of domesticated dromedary camels at the turn of the first millennium BCE, the interregional trade in precious commodities from Arabia, including spices and incense, extended to include overland routes from southern Arabia northwards to the Levant and on to the markets of West Asia and the Mediterranean broadly.[14]

Contact and occasional trade between Mesopotamia and the Arabian Peninsula was already underway during the third and second millennia BCE. The ever-increasing power of temple and palace institutions

[13] On Neo-Assyrian royal gardens, see further Stronach 1990; Novák 2002; Amrhein 2015.

[14] Thanks to the growing number of archaeological efforts and research projects focused on the Arabian Peninsula at the time of writing, information on these routes and relationships continues to evolve at a notable pace. Select publications include Potts 1988 for the first comprehensive analysis, and more recently, Liverani 1992; Singer 2007; Boivin & Fuller 2009; Luciani 2016; Laursen & Steinkeller 2017; Laursen & al-Otaibi 2022; Städtler 2023; and with a focus on the first millennium BCE, Ephʿal 1982; Macdonald 1995; 1997; Byrne 2003; Hausleiter 2012; Magee 2014; Frahm 2017; Hausleiter, Eichmann & al-Najem 2018 (especially Bagg's contribution); Loreto 2019, 2021; Bennett 2024 (especially 39–62).

and of individual rulers and their dynasties across Mesopotamia — which naturally waxed and waned and shifted throughout this period — supported such largescale trade endeavors, not only establishing the connections and recruiting the means necessary to carry out these activities, but also creating the demand for such commodities. Long-distance trade of this type included a combination of both overland and maritime routes. Dilmun, for example, with its capital on Bahrain Island located in the Arabian Gulf, acted as an intermediary in the trade of exotic commodities (frankincense, myrrh, precious metals, semiprecious stones, and textiles) from the Arabian Peninsula by way of maritime travel to southern Mesopotamia, then regions further north, including (i) Assyria and the Levant via the Euphrates River and (ii) the Indus Valley, from the third millennium BCE onwards. An Old Babylonian Sumerian literary text, *Enki and Ninhursag*, recorded on a tablet from Ur describes the land of Dilmun as the 'harbor warehouse of the homeland,' and then proceeds to list nearby lands and the tribute they provide (e.g., Magan, *meš* and *abba* wood) (Attinger 1984; Konstantopoulos 2018: 13–14). A text from the city of Ur in southern Mesopotamia lists an aromatic from Magan (modern Oman) in the context of a recipe list for sesame oil, while inscriptions of both the first ruler of the city-state of Lagash, Ur-Nanše (reign ca. 2500 BCE), and the Akkadian king Sargon (reign 2334–2279 BCE) refer to boats of Dilmun.[15] During the Kassite dynasty, which ruled southern Mesopotamia from the city of Babylon during the second half of the second millennium BCE, its rulers gained control over Dilmun, installing a Kassite governor (*šakkanakku*) and therewith bolstering trade relations between these regions (Potts 2006). Land routes traveled by donkey caravans further increased trade connections between southern Arabia and the Levant as well as Mesopotamia and further east in the second millennium BCE.

During the first millennium BCE the connection between Assyria and the kingdoms of Arabia increasingly shifted away from that of simple trade aimed at acquiring exotic commodities to one of imperial control. Arabian myrrh is first attested in an inscribed tablet from Aššur of the Assyrian king Tukultī-ninurta II (reign 890–884 BCE); in this text the aromatic is simply listed among the tribute given by local rulers at Ḫindanu and Sirqu, both cities on the banks of the Euphrates, and Dur-Katlimmu, a city on the lower Khabur River (Grayson 1991: Tukultī-Ninurta II A.0.100.5, 77, 91, 107). The text inscribed on the so-called Kurkh Monolith of the Assyrian king Šalmaneser III (reign 858–824 BCE) records the king receiving as tribute camels from 'Gindibu', the Arab' (^{m}*gi-in-di-bu-u*' ^{kur}*ar-ba-a-a*) — the earliest preserved attestation of the term 'Arab' (*Aribi*) in Akkadian sources (Grayson 1996: Shalmaneser III A.0.102.2, 94). Here, the term is qualified by KUR, a determinative designating land, while ensuing sources use either KUR or LÚ, a determinative for people — a variation in scribal practice that reveals the Assyrians' persistent uncertainty regarding the different groups, social dynamics, leaders, and kingdoms of the Arabian Peninsula.[16]

As part of growing economic pursuits and imperial expansion that kicked off in the second half of the eighth century BCE, Neo-Assyrian kings conducted military campaigns westward into the Levant, concurrently appointing local officials and imposing tribute on vassal states as they moved through the region. One obvious objective was to control the northern termini of the trade routes connecting with the Arabian Peninsula and which supported the movement of aromatics among other luxury items. In time these contacts and relations (direct with northern and eastern Arabia and indirect with central and southern Arabia) guaranteed for Assyria the economic, ideological, and performative benefits of greater access to these resources, alongside the imperial and militaristic advantages that came

[15] The recipe list from Ur is UET 3 1017:12 (Zimmerle 2014: 338–339). For the Ur-Nanše text, see Frayne 1998: Ur-Nanshe E1.9.1.2, 1–6; see also, E1.9.1.5, 17, 20, 22, 23, 25; and for the Sargon text, see Frayne 1995: Sargon E2.1.1.11, 1–13. See further, Oppenheim 1954; Oates et al. 1977; Crawford 1998; Potts 2007.

[16] See further Frahm 2017: 300; Bagg 2018: 248–249; and Bennett 2024: 1–12 for a nuanced discussion of this term (rendered variably as *Arabi, Aribi, Aribu, Arubu*) and the conception of the 'Arabs' in Assyrian sources, the latter source with a focus on its use in the expression 'Queen of the Arabs' (*šarrat* KUR/LÚ.*aribi*), and defined by Bagg as follows: '*Aribi* ist zunächst eine allgemeine Bezeichnung für Nomaden der syrischen und nordarabischen Wüste, kann sich aber auch auf spezifische Stämme der arabischen Halbinsel beziehen: *Ḫajappa*, *Ibādidi*, *Idiba'il*, *Marsīmani*, *Qidru*, *Sumu'il* und *Tamudi*.' The sources discussed in this chapter include those connected with Arabia, understood geographically as the Arabian Peninsula, and not solely those that include the label 'Arab' in the Assyrian sources.

Figure 9. *Relief panel showing Hanunu of Gaza before Tiglath-pileser III. Gypsum. Iraq, Kalḫu (Nimrud), Northwest Palace (reused in the Southwest Palace). Neo-Assyrian period, reign of Tiglath-pileser III (ca. 728 BCE). British Museum, BM 118933. © The Trustees of the British Museum.*

with maintaining some level of control at this southern extremity of the empire.[17]

In 738 BCE the Assyrian king Tiglath-pileser III (reign 744–727 BCE) conquered Unqi (Patina) and Ḫatarikka in northern Syria, resulting in the receipt of gifts from several western rulers, including 'Zabibē, queen of the Arabs' (Tadmor and Yamada 2011: Tiglath-pileser III 15, 2).[18] Subsequently, in 734 BCE Tiglath-pileser III defeated king Ḫanunu of Gaza and turned the city into an Assyrian trading station (*bīt kāri*), thereby imposing control over an area that was the traditional terminus for caravans bringing incense and spices from the peninsula to the Mediterranean coast (Na'aman 2004). In addition to recording this history in his royal inscriptions, Tiglath-pileser III also memorialized the event in the sculptured program of his palace at Kalḫu (Tadmor and Yamada 2011: Tiglath-pileser III 42, 8′b–15′a) (Fig. 9). Assyrian control was strengthened the following year when the king successfully campaigned at Mount Saqurri, an area south of Damascus (possibly present-day Jabal al-Drūz),[19] against 'Samsi, queen of the Arabs', a ruler from northern Arabia from whom the king took 'all types of

[17] See further, Bagg 2018 (especially Karten 1–2 and related discussion), who concludes that, although Assyria subjugated areas of the Arabian Peninsula through both militaristic and political means, this never led to territorial annexation; and on the potential military benefits, see Bennett 2024: 60–62, who also considers Assyria's relations with Egypt and Babylonia at the time: 'The Assyrians clearly understood the 'Arabs' were in control of two vital resources that could be exploited: dromedaries, and knowledge of how to cross the desert safely. Assyria deployed several methods for controlling the 'Arabs' as well as dromedaries and the ability to cross the desert in a safe manner. The methods included grazing rights; formal loyalty oaths; restricting access to iron; and military conquest.'

[18] On Zabibē and the 'queens of the Arabs' named subsequently in this section, see the respective entries with sources and analysis in Bennett 2024, where they are organized by the reigns of individual Assyrian kings.

[19] See the discussion in Ephʿal 1982: 85; Bennett 2024: 84.

aromatics;' he subsequently received the same among other luxury items as gifts from cities 'on the border of the western lands' — including Tēma (Taymāʾ), the caravan oasis and religious centre in north-west Arabia — all of whom wanted to appease the recently victorious king (Tadmor and Yamada 2011: Tiglath-pileser III 42, 19′b–22′, 27′–33′):

> As for Samsi, queen of the Arabs, at Mount Saqurri, I defeated 9,400 (of her people). I took away (from her) 1,000 people, 30,000 camels, 20,000 oxen, ..., 5,000 (pouches) of all types of aromatics, ..., thrones of her gods, the military equipment (and) staffs of her goddess(es), (and) her property.
>
> The people of the cities Masʾa (and) Tēma, the (tribe) Saba, the people of the cities Ḫayappa, Badanu, (and) Ḫatte, (and) the (tribes) Idibaʾilu, ... , who are on the border of the western lands, whom none (of my predecessors) had known about, and whose country is remote, heard about the fame of my majesty (and) my heroic deeds, and (thus) they beseeched my lordship. As one, they brought before me] gold, silver, camels, she-camels, (and) all types of aromatics as their payment and they kissed my feet.

The relief panels from the Central Palace of Tiglath-pileser III at Kalḫu include a visual rendering of this encounter, one panel showing Assyrian cavalrymen pursuing two men on dromedaries and a second, a captive woman leading a group of camels (Figs 10–11).[20] The woman's dress — a long, fringed garment, cloak, head covering, and triple bracelets on both wrists — suggests an elite status, likely that of a queen and specifically Samsi[21]; in her left hand she holds a beautifully rendered loop-handled vessel, perhaps of a type that was used to transport or burn aromatic resins. In 732 BCE, Tiglath-pileser III successfully conquered and annexed Damascus and ultimately dismantled Aramaean control of the region.

Further campaigns to this nexus of trade were staged under the Assyrian king Sargon II, who confronted an opposing alliance — between the same ruler of Gaza, Ḫanunu, and Egyptian troops — in a battle at Rapiḫu (modern Raphia), a city just south of Gaza. With this victory in 720 BCE, Sargon once again reinforced Assyrian control of routes running through Gaza (Frame 2021: Sargon II 7, 25b–26):

> Ḫanūnu (Hanno), king of the city Gaza, with Rēʾe, the field marshal of Egypt, rose up to do war and battle against me at the city Rapḫia. I brought about their defeat. Rēʾe took fright at the clangor of my weapons and fled; his whereabouts have never been discovered.

Sargon II's royal inscriptions also record a victory in 715 BCE against 'Arab' tribal groups, whom he claims to have deported and resettled; next the text describes the tribute he received from the king of Egypt and rulers in Arabia, including 'Samsi, queen of the Arabs,' and It'amar (Yita''mar), ruler of Saba' (Sheba), the largest and wealthiest of the kingdoms of southern Arabia at the time and the principal state for the trade of frankincense (Frame 2021: Sargon II 1, 120b–125a):[22]

> (As for) the Tamudu, Ibādidi, Marsīmani, (and) Ḫayappa (tribes), faraway Arabs who live in the desert, did not know (either) overseer (or) commander, and had never brought their tribute to any king, I struck them down with the sword of the god Aššur, my lord, deported the remainder of them, and (re)settled (them) in the city Samaria.
>
> I received as tribute from Pirʾû (Pharaoh), king of Egypt, Samsi, queen of the Arabs, (and) Itʾamar, the Sabaean, kings from the seashore and desert, gold — ore from the mountain(s) — precious stones, elephant ivory, seed(s) from ebony tree(s), every kind of aromatic, horses, (and) camels.

Worth noting is a relief panel from Corridor 10 of Sargon II's palace at Dur-Šarrukin that shows in its upper register a male figure leading three dromedaries within the context of a longer procession of tributaries

[20] On this and depictions of dromedaries in Assyrian visual culture discussed subsequently, see further Mitchell 2000.

[21] This identification is similarly argued by Bagg (2018: 254) and Bennett, who also makes an argument for a sketch of Sir Austen Henry Layard, showing a woman atop a dromedary fleeing battle (BM 2007,6024.305), as being an additional depiction of Samsi (2024: 78–82, figs 4–5).

[22] See further the discussion in Frame 2021: 23–30 on Sargon II's military campaigns.

Figure 10. *Relief panel showing two Assyrian cavalrymen pursuing two men on dromedaries. Gypsum. Iraq, Kalhu (Nimrud), Central Palace. Neo-Assyrian period, reign of Tiglath-pileser III (ca. 728 BCE). British Museum, BM 118878. © The Trustees of the British Museum.*

Figure 11. *Relief panel showing a female figure leading four dromedaries. Gypsum. Iraq, Kalhu (Nimrud), Central Palace. Neo-Assyrian period, reign of Tiglath-pileser III (ca. 728 BCE). British Museum, BM 118901. © The Trustees of the British Museum.*

bringing gifts to the king.[23] Construction of the palace began around 717 BCE when this new capital city was founded; however, work was still not complete at the time of the king's death in 705 BCE, a year after he moved into Dur-Šarrukin.

Sargon's son and successor, Sennacherib (reign 704–681 BCE), swiftly moved the Assyrian court and central administration to the city of Nineveh, some twenty kilometers to the south, where he too carried out substantial state-sponsored building projects. In an inscription from 694 BCE, Sennacherib records assigning to a newly constructed gate (the 'Desert Gate') at Nineveh the full name 'The Gifts of the People of Sumu'il and Tēma Enter Through It,' attesting to the continued consumption of Arabian commodities in Assyria (Grayson & Novotny 2012: Sennacherib 17, vii 96; see also Sennacherib 18, vii 37′–38′). As discussed by Daniel Potts (1991) and Eckart Frahm (2017), both of these north Arabian sites were integral in Assyria's ability to maintain connections with the Arabian Peninsula at large. In addition to controlling trade, Assyria may have also had a cultural influence on these settlements: both scholars cite a fragmentary relief found at Tēma in 1884 as having an Assyrian style, 'suggesting that Tēma's local elites sought to emulate Assyrian culture' (Frahm 2017: 302; Musée du Louvre [AO 29143]). Based on a funerary stele discovered at Tēma in 2011 with a comparable and gratuitously more complete relief carving, Arnulf Hausleiter (2019; object number TA 10277) argues for a fourth/fifth-century BCE date for the creation for both objects and the inclusion of 'both Syro-Hittite and Assyrian iconographic elements' in their design — the result of a 'local selective choice' and a 'strong iconographic memory' (Hausleiter 2019). Noteworthy is that references to Tēma appear in Neo-Assyrian royal inscriptions already during the reign of Tiglath-pileser III, as noted above, yet the first cuneiform reference to the city comes from a Babylonian source, specifically an inscription of Ninurta-kudurri-uṣur, governor of Suḫu and Mari in the mid-eighth century BCE, who claims to have confiscated goods of a caravan from Saba' and Tēma (Frame 1995: Ninurta-kudurrī-usur S.0.1002.2, iv 27′).[24]

Likely in 690 BCE, Sennacherib campaigned to Arabia, going further south than any previous Assyrian king. Here, he cites encounters with 'Te'elḫunu, queen of the Arabs,' from whom he took thousands of camels and after which she fled to the city of Adummatu. The text continues to detail the king's claim to have next carried the queen off along with her gods, precious stones, woods, and all types of aromatics following the destruction and devastation of multiple cities, understandably including Adummatu (Grayson & Novotny 2012: Sennacherib 35, r. 3″b–9″).[25] A group of six cylinder-shaped stone beads excavated at Nineveh may very well have been among those precious stones that were brought back to Assyria: their inscriptions name Sennacherib and designate each as 'booty of the city Dumetu/Duma,' likely identical with Adummatu (Grayson & Novotny 2012: Sennacherib 111–116 [BM 89290, 89919, 89913, 89915, 82-5-22,324, 89914]; Bennett 2024: 115).

Inscriptions from later in Sennacherib's reign (after 689 BCE) record the king's receipt of precious stones and gum-resins as tribute from a ruler of Saba', Karib-il. Engraved on another group of six cylinder-shaped beads, also recovered from Nineveh, are inscriptions stating that these beads were given as an audience gift to Sennacherib from Karib-il; the beads are of banded agate, chalcedony, and onyx (Grayson & Novotny 2014: Sennacherib 103–108 [BM 89910, 89912, 89918, 89908, 89291, 89926]). The text on a large stone tablet from Aššur that dates to around 683 BCE describes Sennacherib's construction of a temple, specifically the *akītu*-house at Aššur, and similarly mentions stones as well as aromatics gifted by Karib-il (Grayson & Novotny 2014: Sennacherib 168, 48–55 [VA 8248]):

> While laying the foundation of the *akītu*-house, the audience gift of Karib-il, king of the land Saba —

[23] A drawing of the full relief panel is included in Botta & Flandin 1849–1850: pl. 128; part of the panel is preserved in the collections of the Institute for the Study of Ancient Cultures Museum (A7361) (Loud 1936: fig. 55).

[24] See Edmonds 2024 for a new chronology, sequence of governors, and political history for Suḫu, which was situated on the Middle Euphrates and a crucial trade route between Assyria and Babylonia.

[25] See further Grayson & Novotny 2021: 9–15 on Sennacherib's military campaigns, and on the city of Adummatu (identified in modern scholarship as present-day Dumat al-Jandal), see Bagg 2018; Loreto 2019; 2021; Bennett 2024: 43–44. See also the reference in Esarhaddon's royal inscriptions to this conquest of Adummatu by his father and the removal of Te'elḫunu, her gods, and other valued possessions to Assyria, which Esarhaddon claims to have returned (Parpola 2017: Esarhaddon 1, iv 1–16).

> *pappardilû*-stone, choice stones, (and) fine aromatics — was presented to me and from that audience gift I laid stones (and) aromatics in its foundations. Like ..., I ... silver, gold, carnelian, lapis lazuli, *hulālu*-stone, *muššaru*-stone, *pappardilû*-stone, *papparmīnu*-stone, *dāmātu*-paste, (and) all the finest aromatics in the foundation of that *akītu*-house. I sprinkled that foundation with perfumed oil (and) fine oil as (abundantly) as river water.

A preceding section of the same inscription mentions the people of Dilmun in the context of Sennacherib's destruction of the city of Babylon, which took place in 689 BCE (36–41):

> After I destroyed Babylon, smashed its gods, (and) put its people to the sword, I removed its earth in order to make the site of that city unrecognizable and I had (it) carried to the sea by the Euphrates River. (When) its dirt reached Dilmun and the people of Dilmun saw (it), fear (and) terror of (the god) Aššur fell upon them and they brought their audience gift(s) to me.

The succeeding Assyrian king, Esarhaddon, tried to maintain good relations between Assyria and Arabia and the receipt of tribute in return — for example, the king's royal inscriptions record the receipt of tribute from Qana, the king of Dilmun (Leichty 2011: 60, 5′). However, occasional campaigns to the region were necessary when leaders refused to pay tribute and threatened Assyria's control. Recounted in the king's royal inscriptions are an expedition in 677/76 BCE against Bāzu, likely located in north-eastern Arabia (Leichty 2011: 1, iv 53–77), and encounters with 'Arab kings', from whom he acquired camels and water supplies while traveling through the Sinai Peninsula in 671 BCE on route to Egypt — his second campaign against the latter (Leichty 2011: 34, r. 1–8; see also Radner 2008; Frahm 2017: 304–305).

Aššurbanipal, Esarhaddon's son and successor, was the last Assyrian king to attempt to maintain the far-flung borders and commercial endeavors of the Assyrian state, as well as the receipt of tribute from rulers in Arabia. For example, preserved sections of an inscription from the unsculptured wall panels of the Ištar temple at Nineveh tell of the ring receiving tribute from eastern Arabia, including from Ḫundāru, king of Dilmun; Padê, king of the land of Qadê (ancient Magan); and 'Šīlmun, a king of the steppe who lives in the land Ḫazmāni, (which is) on the shore of Dilmun, in the middle of the sea' (Novotny & Jeffers 2018: Ashurbanipal 23: 131b–139a). Yet Aššurbanipal faced even greater challenges than his predecessors when it came to the Arabian Peninsula, due in part to growing alliances between his rebellious brother Šamaš-šumu-ukin, then king of Babylon, and rulers in Arabia. In response, twice — in 652 BCE at the latest and in 645 BCE (what are commonly referred to as the king's 'Arab campaigns') — Aššurbanipal sent to the region troops who successfully suppressed revolts and even brought back to Assyria rulers from Arabia, some of whom he claims to have tortured and/or put to work as common labourers (Novotny & Jeffers 2018: Ashurbanipal 8 and 11). Like his predecessor Tiglath-pileser III, Aššurbanipal represented this first campaign to Arabia in the relief panels of his North Palace at Nineveh (Barnett 1976: 45, pl. XXXIII [BM 124925–124927]; see further Bennett 2024: 153–158).

Contact with either the leaders or region of Arabia is not recorded for any subsequent Assyrian kings, all of whom faced growing internal tension as well as attacks from external forces. Ultimately, in 612 BCE the Assyrian Empire fell to an alliance of Medes and Babylonians, leaving the caravan trade connecting to southern Arabia and the benefit of its commodities up for grabs. Notwithstanding, early Neo-Babylonian rulers maintained a mere tributary relationship with their western periphery, modelling their interest in and administrative practices toward this region only minimally on those of their Assyrian predecessors.[26]

The midpoint of the reign of the Neo-Babylonian king Nebuchadnezzar II (ca. 585 BCE; reign 605–562 BCE) marked a shift: with a stable core and ability to invest outwards, the king dedicated more time and resources to this western periphery, even seeking to establish a Babylonian presence there. Moving the needle even further was the last Neo-Babylonian king, Nabonidus, whose keen interest in controlling the caravan trade routes in north-west Arabia strengthened connections between Mesopotamia and the aromatics industry of southern Arabia, resulting in an increase in frankincense cultivation overall. Rather than relying

[26] On the Neo-Babylonian kings' connections with and activities in the Arabian Peninsula, see Beaulieu 1989, 2018; Levavi 2019; in addition to the sources cited in notes 14, 27, and 28.

Figure 12. *Stele fragment with relief carving and inscription. Saudi Arabia, Tēma. Neo-Babylonian period, reign of Nabonidus, when in Tēma (553–543 BCE). TA 488. © DAI, Orient Department, and Heritage Commission, I. Wagner with additions by H. Hamel*

on the preexisting routes that ran northward through the southern Levant and then toward Mesopotamia, Nabonidus established trade routes running eastward from northern Arabia to Babylonia. By bringing these precious commodities directly to Babylonia, the king avoided the additional taxation and tolls of the southern Levantine routes.

Located along this eastward route in north-west Arabia was Tēma, the caravan oasis where, after campaigning to the region (most likely in the year 553 BCE), Nabonidus remained for no less than a decade; his son Belshazzar (Bēl-šarra-uṣur) served as regent in Babylonia during his absence.[27] Akkadian inscriptions written in Neo-Babylonian script from Tēma and Taymanitic inscriptions found in the vicinity of the oasis, as well as cuneiform rock inscriptions from ancient Padakku/Fadak, the modern town of al-Ḥaiʾṭ in the Ḥāʾil province, all attest to the king's presence in the region, many including the king's own name and some the names of individuals who served in his campaigns. What is more, the al-Ḥaiʾṭ rock inscriptions — of which two have been uncovered — and a stele fragment from Tēma (Fig. 12) include relief carving that represents the body of the king standing in a gesture of prayer and surmounted by divine symbols in typical Mesopotamian fashion — imagery most well-attested on first-millennium BCE Assyrian and Babylonian royal steles.[28] The text on the stele fragment from Tēma, albeit

[27] For a discussion of reasons for Nabonidus' lengthy residence in Tēma, see Hausleiter 2012: 823; Livingstone 2005; Beaulieu 2018: 239–242; Schaudig 2020; Bennett 2024: 45, fn. 194.

[28] On the Tēma cuneiform inscriptions, see Schaudig 2020; Weiershäuser & Novotny 2020: Nabonidus 56–61; Eichmann, Schaudig & Hausleiter 2006; and on the stele fragment (TA 488) specifically, Schaudig 2020: 11–13; Weiershäuser & Novotny 2020: Nabonidus 56; Eichmann, Schaudig & Hausleiter 2006: figs 8, 12–13. On the Taymanitic texts, see Müller & al-Said 2002; Livingstone 2005; al-Said

minimally preserved, speaks of the king fashioning an incense burner of shining gold (NÍG.NA KÙ.GI SIKIL / *nignakku hurāṣi elli*) in the context of his rebuilding of a temple (possibly Eḫulḫul, 'House which Gives Joy', the temple of the moon-god Sin at Ḫarran), thereby affirming the continued importance of olfaction in ritualized practice. With the downfall of the Neo-Babylonian Empire (539 BCE), the ensuing Achaemenid Empire (550–330 BCE) expanded westward and usurped a degree of influence and authority over some of the same routes and relationships with local rulers in Arabia as their first-millennium BCE predecessors; while specifics of this connectivity remain uncertain, the Achaemenid kings and their empire certainly continued to benefit from the highly sought-after resources of the region.[29]

Otherwordly conceptions

Textual sources and visual imagery from Assyria communicate a cultural view of these regions from which aromatic substances originated — i.e., the mountains, forests, and desert lands — not only as distant and foreign, but also as exotic, inaccessible, liminal, and otherworldly. This 'otherness' of such landscapes is apparent for the cultures of Mesopotamia broadly, with several literary texts placing heroic deeds and battles between gods and monsters in these geographically remote places; figures in these tales also often carry out long journeys (Dalley 2016; Konstantopoulos 2018). The well-known battle between the heroic king Gilgamesh and the grotesque king of the Cedar Forest, Humbaba, is one such example (George 1999). Related, the concept of Mount Amanus, as constructed by Neo-Assyrian texts and characterized by Allison Thomason, is that of 'a quasi-mythical site where heroes roamed and exotic sensual experiences would occur' (Thomason 2005: 174; see further, Ponchia 2004; 2006). Here, I reiterate the description of the Zagros Mountains from Sargon II's inscriptions: 'high mountains that are thickly covered with all kinds of trees, among which (one becomes completely) confused (as to direction), whose very entry is terrifying, (and) over whose (whole) environs, just as in a cedar forest, a shadow is cast with the result that the one who takes the road through them sees no sunlight.'

Assyrian accounts of desert landscapes similarly emphasize their far-off and otherwordly qualities that markedly contrast with the heartland of Assyria and its capital cities. Aššurbanipal's accounts of one of his troops' campaigns in Arabia is poignantly descriptive (Novotny & Jeffers 2018: Ashurbanipal 11, viii 80–96):

> They (my troops) safely crossed the Tigris and Euphrates Rivers when they were in full spate, traveled on remote paths, climbed high mountains, crept through forests whose canop(ies) were wide, (and) constantly passed safely between tall trees, thorn bushes, brambles, (and) paths (filled with) *eddittu*-bushes. (Over) desert (*madbaru*) — a place of parching thirst in which no bird of the heavens flies (and) where no onagers (or) gazelles graze — a distance of one hundred leagues from Nineveh, the city loved by the goddess Ištar — the wife of the god Enlil — they advanced (and) marched in pursuit of Uaiteʾ, the king of the land of the Arabs, and Abī-Yateʾ, who had come with forces of the land of the Nabayateans.

In a later section of this same inscription, the desert is again presented as an inhumane landscape — with emphasis placed on the lack of water — when the king recounts a campaign to the city of Ḫurarīna and the defeat of the Yisamme' and the Nabateans (viii 100–121):

> I set out from the city Ḫadattâ (and) set up my camp at the city Laribda, a stone fortress next to water cisterns. My troops drew water to (fill) their drinking vessel(s), and (then) advanced (and) marched (through) a land of parching thirst (lit. 'a land of thirst (and) a place of parching') as far as the city Ḫurarīna, (which is) between the cities Yarki and Azalla, in the desert (*madbaru*), a distant place where there are no creatures of the steppe and (where) no bird of the heavens makes (its) nest. They (lit. 'I') brought about the defeat of the Yisammeʾ, the confederation of the god Atar-samayin, and the Nabayateans. They (lit. 'I') plundered countless people, donkeys, camels, and sheep and goats. My troops marched about triumphantly over a distance of eight leagues. They

2009. On the al-Ḥaiʾṭ cuneiform rock inscriptions with relief carving, see Hausleiter & Schaudig 2016 (discovered in 2012) and *Arab News* 2021 (discovered in 2021 and being studied by the Saudi Heritage Commission and the German Archaeological Institute at the time of writing). On Mesopotamian steles depicting the king with divine symbols, see Bahrani 2017: 259–262, 277–278.

[29] On Arabia during the Achaemenid period, see Graf 1990; Rohmer 2021; Graf & Hausleiter 2021.

> returned safely and drank water to (their) satisfaction in the city Azalla.

This characterization perfectly aligns with the account in Esarhaddon's inscriptions, noted above, of his having to rely on 'Arab kings' for camels and water supplies — i.e., on the knowledge of those familiar with this 'other' landscape — when travelling toward Egypt.

The inscriptions of earlier Neo-Assyrian kings similarly present desert landscapes as inhospitable and desolate. Tiglath-pileser III's inscription detailing his defeat of 'Samsi, queen of the Arabs,' includes the following description of the desert (Tadmor & Yamada 2011: Tiglath-pileser III 42, 22–25):

> Moreover, she, in order to save her life, ... (and) set out like a female onager to the desert (*madbaru*), a place (where one is always) thirsty. I set the rest of her possessions (and) her tents, her people's safeguard within her camp, on fire.

Sargon II's inscriptions describe the desert as 'an arid land, a waterless region (lit.: 'place of thirst') and suggest that both mountains and deserts as places where thieves roam (Frame 2021: Sargon II 65, 188; 1, 184). Sennacherib's inscriptions similarly describe the desert as 'a place of thirst in which there is no pasture (or) watering-place' (Grayson & Novotny 2012: Sennacherib 36, 57′). Esarhaddon's account of his expedition to Bāzu in north-eastern Arabia effects an otherwordly and harsh image of this land, much like the text of Aššurbanipal above (Leichty 2011: Esarhaddon 2, iii 9–14):

> (As for) the land Bāzu, a district in a remote place, a forgotten place of dry land, saline ground, a place of thirst, one hundred and forty leagues of desert, thistles, and gazelle-tooth stones, twenty leagues of land where snakes and scorpions fill the plain like ants — I left mount Ḫazû, the mountain of *saggilmud*-stone, twenty leagues behind me and crossed over (to that district) to which no king before me had gone since earliest days.

Later Greek historians writing about frankincense and myrrh obtained via the incense trade route suggest that Arabian tradesmen kept the real source of these aromatics a secret, imbuing these commodities with further fantasy and prestige, echoing the Assyrian conception (Ben-Yehoshua, Borowitz & Hanuš 2012: 8).

Imagery reinforces this conception of aromatics-producing regions as far-off, exotic, and otherwordly. Visual renderings of highlands and mountain ranges, for example, emphasize their vast and undulating rolling hills. Scenes on bronze relief bands from the doors of an Assyrian palace at Imgur-Enlil (modern Balawat), for example, depict Assyrian soldiers carrying logs through such a landscape (Schachner 2007: 185–186, pl. 63 (Band N) [Walters Art Museum 54.2335]). The maritime transport of logs is also preserved visually, specifically in the relief panels of Sargon II's palace: here, creatures and mythological guardian figures (e.g., *lamassu* and a merman) are shown alongside boats bearing logs amid great, majestic waves (Botta & Flandin 1849–1850: I, pl. 33 [AO 19888–19891]). Reinforcing the foreignness of these trees and their aromatic substances, as well as modes of transport, are those tribute scenes that depict rulers from the empire's borders gifting to Assyrian kings logs, containers that might be carrying resins (as suggested by the scene of the elite woman, possibly Samsi, with vessels in hand from Tiglath-pileser III relief panels), and camels (e.g., the tribute bearers from the west leading dromedaries in the relief panels of Sargon II at Dur-Šarrukin).

Conclusion

> The mental maps created by the peoples of the ancient world are inherently messy, and the ways in which they thought and conceived of the world they lived in, including the lands at and beyond its outermost edges, did not necessarily follow linear trajectories. During a journey from the familiar to the foreign, a 'more distant' location may appear, hosting even more fantastical settings and creatures. It is clear that distance, and the idea of othering what is found at its edges, exists on both large and small scales. (Konstantopoulos 2018: 14–15)[30]

The wealth of written sources, visual imagery, and archaeological material associated with the burning of incense testifies to the pervasive and pivotal role of olfactory practices in Assyria, especially in the

[30] Bagg (2018) also uses the concept of a 'mental map' in her analysis of the Assyrians' conception of the 'Land of the Arabs' (*māt aribi*) along the empire's southern border.

context of communicating with and caring for divinity. Yet aromatic, gum-producing trees were scarce to the Assyrian heartland, necessitating effective alternative means for the acquisition of incense's raw materials. The olfactory offerings of southern Arabia were not exploited as early as the mountain ranges and forests to the east and west of Assyria, yet in time Neo-Assyrian kings became determined to be beneficiaries of — both sensorially and economically — the intoxicating and lucrative aromatics native to southern Arabia, a determination that only continued and notably expanded under the kings of succeeding empires who equally reaped the benefits of controlling the associated trade routes. Much like the lands to the east and west, the far-off and unfamiliar qualities of Arabia — with its desert landscapes, nomadic groups, female rulers, and powerful kingdoms — materialized in the Assyrian world view a real yet fantastical place, attainable yet inaccessible, inhabited yet inhospitable, tangible yet liminal. Kings, troops, and merchants had to transgress 'from the familiar to the foreign' through long journeys, trade, and military expeditions in order to secure access to Arabia's aromatics. In the Assyrian view of the world such rigorous modes of acquisition amplified the exotic and supernatural associations of these commodities, enhancing the value and meaning of the intoxicating smoke they ultimately produced.

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Aššurbanipal's bdellium: revisiting *Commiphora wightii* in the Persian Gulf

Sureshkumar Muthukumaran

Summary
Bdellium, the aromatic oleo-gum resin produced by the Indo-Arabian *Commiphora wightii*, has been valued in many Afro-Eurasian cultures since antiquity. This paper re-assesses the earliest history of this commercially significant botanical resource and the terminology associated with this plant in various ancient languages, with a particular focus on sources in the Akkadian language of Mesopotamia. In the process, the paper reiterates the significance of south-eastern Arabia (modern Oman) as a source of bdellium for ancient Afro-Eurasian communities.

Keywords: *Commiphora wightii*, Bdellium, Akkadian, Mesopotamia, Oman

Introduction: the genus *Commiphora*

The genus *Commiphora* includes a number of commercially valuable spinescent resiniferous shrubs or small trees that are distributed throughout tropical and sub-tropical Africa, Asia, and South America (Daly et al. 2022: 94). The plants of this genus are primarily exploited for their aromatic but bitter-tasting oleo-gum resin, which is produced when the bark is wounded. The resin is valued as incense, a fixative in perfumery, and for diverse medical applications (Dekebo et al. 2022). Myrrh, derived primarily from *Commiphora myrrha*, a native of Somalia, Ethiopia, and south-west Arabia, is the best known product of this genus. The anthropic use of myrrh is attested in Middle Eastern and north-east African textual and archaeological contexts from the 2nd millennium BCE on. The equation of the Akkadian *murru* with myrrh is generally not doubted owing to multiple lexical and contextual correspondences in later languages e.g. Phoenician *mr*, Hebrew *mōr*, Greek μύρρα/ σμύρνα (Myer 1975: 97–101). In any case, chromatographic and spectroscopic analysis of a vase with resinous substances from a 12th or 13th dynasty tomb at Dahshur in Egypt provides more definitive evidence for the use of myrrh in a 2nd millennium BCE context (Goyon et al. 1999).

The first millennium BCE saw Middle Eastern and Mediterranean communities gaining wider access to other *Commiphora* species of African, Arabian, and Indian origin. Among these were *Commiphora gileadensis*, the source for the balm of Gilead or balm of Mecca, which is widely distributed across north-east Africa and the Arabian Peninsula. Unlike many other commercially valuable *Commiphora* species, the aromatic compound extracted from the bark, wood, and fruits of *Commiphora gileadensis* remains in liquid state. The cultivation of this thorny shrub was introduced at Ein Gedi and Jericho during the reign of King Josiah of Judah (c. 640–609 BCE) (Hirschfeld 2007: 29–30). While other *Commiphora* species are generally exploited in their wild habitats, *Commiphora gileadensis* was exceptional in being a successful and lucrative tree crop beyond its native range. It is nowadays commercially insignificant but found widespread appeal in antiquity. Fruits and seeds of *Commiphora gileadensis*, probably sourced from Gebel Elba near the modern border between Egypt and Sudan, have, for example, been retrieved from 1st–2nd and 4th–6th centuries CE horizons at the Roman Red Sea port of Berenike (Cappers 2006: 80–82). Besides *Commiphora gileadensis*, other Afro-Arabian *Commiphora* species that may have been exploited for resin extraction in antiquity include *Commiphora kua*, *Commiphora guidottii* (bisabol myrrh), *Commiphora kataf*, *Commiphora foliacea*, and *Commiphora africana.* The last of these, however, is not particularly resinous.

Figure 1. *Commiphora wightii at Sikar, Rajasthan, India. (photo: Tara Chand Saini via India Biodiversity Portal, 2015 (CC BY)).* https://indiabiodiversity.org/files-api/api/get/raw/observations//4f6ecdac-075a-4b43-9b35-172cc35ba124/56.JPG

Commiphora wightii

Commiphora wightii (syn. *C. mukul*), which produces a resin called bdellium, is yet another *Commiphora* species of great significance to a broad range of ancient cultures from India to the Mediterranean. The tree, possessed of a whitish papery bark, grows to heights of 2–3 metres (Fig. 1). It is a drought- and saline-resistant species adapted to growing in semi-arid and arid regions, with a preference for undulating or hilly terrain. The wounded bark yields an aromatic oleo-gum resin that is collected in the form of irregularly shaped masses of varying sizes ranging in colour from the opaque to the dark (Fig. 2). The natural distribution of *C. wightii* includes the arid and semi-arid rocky tracts of north-western South Asia and the Deccan, namely Sindh and Baluchistan in Pakistan, and Rajasthan, Gujarat, Madhya

Figure 2. *Bdellium. (photo: Jacopo Koushan via Wikimedia Commons, Tabriz, 2013 (CC BY-SA 3.0 DEED))* https://commons.wikimedia.org/wiki/File:Bdellium_resin.jpg

Pradesh, Karnataka, and Telangana in India (Asouti & Fuller 2008: 94; Cunningham et al. 2018: 23–24). In recent times, *C. wightii* populations have been subject to overexploitation in both Pakistan and India owing to an insatiable demand for raw and processed bdellium in the pharmaceutical industry (Cunningham et al. 2018: 22–23).

C. wightii also has a disjunctive distribution in south-eastern Arabia although this is not well known as India and Pakistan are the leading exporters of bdellium today. It grows in particular on the rocky limestone slopes of the eastern and western Hajar mountain ranges of Oman (Al Hatmi & Lupton 2021; Hinai, Lupton & Al Issai 2020; Patzelt 2015: 293, 299). The tree is also recorded in the Dhofar region of southern Oman, for example at Wadi Afal and Wadi Mughsayl (Radcliffe-Smith 1980: 80; Raffaelli, Mosti & Tardelli 2003: 143; Miller & Morris 1988: 82) and in the rocky hillocks between Mirbat and Sadah (Miller & Morris 1988: 304; Mosti, Raffaelli & Tardelli 2012: 77). Otherwise, *Boswellia sacra*, the source of frankincense, is much more common in the Dhofar region. As in South Asia, bdellium (Arabic *muql*; Jibbali *ʻaḳerít*) has cultural and medical applications in Oman and is available for purchase in local bazaars (Fatope et al. 2003: 1251; Rehman et al. 2019: 434). The powdered form of *C. wightii* resin is mixed with water and used externally for respiratory illnesses and dermatological conditions while smoke from the burnt resin is believed to repel pests and supernatural forces (Al Hatmi & Lupton 2021; Fatope et al. 2003: 1251). The inner bark and fruits are also used as disinfectants (Miller & Morris 1988: 304–305).

Guggulu: the fire god's flesh

It is necessary to briefly discuss the earliest attestations for bdellium in India since the terminology used here will inform our discussion on its status in the Persian Gulf. The *Atharvaveda*, a Vedic Sanskrit ritual text composed around 1000–900 BCE, provides the earliest textual evidence for bdellium, known as *gulgulu* or *guggulu*, in an Indian context. A protective charm in this text (19.38) extols the utility of bdellium. It is described as curative and possessed of a pleasant smell (*bheṣajasya gulguloḥ surabhir gandho*). It was invoked, in particular, to expel a body-wasting disease (*yakṣma*). The same hymn distinguishes between two varieties of bdellium, namely one from the lower Indus region (*saindhava*) and another acquired via maritime routes (*samudriya*). In the case of the latter, the most plausible sources are either coastal Baluchistan or Arabia. But since the bdellium harvested in Baluchistan could have easily moved eastwards through terrestrial routes as well, the explicit reference to an oceanic-derived bdellium indicates that this was possibly sourced further afield in south-eastern Arabia.

Alongside the *Atharvaveda*, a number of other early- to mid-1st millennium BCE Sanskrit texts like the *Taittirīya Saṃhitā*, *Aitareya Brāhmaṇa*, and *Pañcaviṃśa Brāhmaṇa* attest to the ritual uses of bdellium (McHugh 2012: 233–236; Potts et al. 1996: 299–301). It was regarded as a sacred substance and said to be the very flesh of the fire god Agni who carries oblations to other deities (*Śatapatha Brāhmaṇa* 3.5.2.16). The medical uses of bdellium, already alluded to in Vedic texts, are further elaborated in Sanskrit texts belonging to the Ayurvedic tradition of medicine (Raison 1979). In modern South Asia, bdellium (Hindi *guggul*) is well known and has retained both its time-honoured ritual and medicinal roles.

False friends: *guḫlu* and *guggulu*

Turning to the Persian Gulf region, the earliest extant textual materials for bdellium here are to be found in the cuneiform records of Mesopotamia. Modern scholarship has proposed two words as denoting bdellium in Akkadian language records, namely *guḫlu* and *bidurḫu*. In an influential paper, Daniel Potts, Asko Parpola, Simo Parpola, and John Tidmarsh (1996) advanced the claim that the Akkadian word *guḫlu* denotes bdellium and that it was the source for the Sanskrit *gulgulu* or *guggulu*. These conclusions have since been repeated by a number of other linguistic and historical analyses (e.g. Huehnergard 2021: 1513; Middeke-Conlin 2014; Potts 2007a: 70; 2007b: 135; Ray 2003: 85). These claims are, however, fragile as the identification relies unduly on phonological correspondences. The authors underscore the Semitic origin of *guḫlu*, namely its triconsonantal word formation and potential derivation from the root *ḫl* meaning exuding or permeating, from which are derived words like *ḫīlu,* 'exudation (of plants, resins)', *ḫalāṣu*, a verb meaning to press or squeeze out, and the Neo-Assyrian *ḫalāpu*, a verb for milking (Potts et al. 1996: 297). While the evidence may point to *guḫlu* being

some sort of exudate or paste originating in a Semitic-speaking zone, this does not constitute positive evidence for bdellium. Furthermore, a text that is cited as a key source for *guḫlu* in this discussion (Harper 1902: no. 791) involves a mistaken restoration of a fragmentary word, of which only a single syllable is preserved on the original cuneiform tablet. There is firm evidence, as we shall observe later, for restoring the fragmentary word in this context as *bi*[*durḫu*] and not ŠIM.BI.[ZI.DA], the logographic reading for *guḫlu*.

There are persuasive historical and contextual grounds for why the equation of *guḫlu* with bdellium is untenable. Firstly, this claim does not square with the geographic origins of bdellium, which is not native to Mesopotamia and was never grown there. There is no compelling motivation for South Asian communities to adopt the Akkadian word for a plant that grew in the Indian subcontinent. If anything, a borrowing in the reverse direction should be expected in light of *Commiphora wightii*'s geographical distribution. In the case of coriander (*Coriandrum sativum*), a native of the Middle East, the Sanskrit *kustumburu* can be convincingly derived from either the Akkadian *kusibirru* or Aramaic *kusbara* on meaningful linguistic, historical, and contextual grounds. It appears more reasonable to turn to Indian language families in the first instance for identifying a potential source for the Sanskrit *guggulu/ gulgulu*. There are several words with geminate consonants relating to native flora and fauna in the pre-Indo-Aryan Gangetic substrate language. The latter has been identified as a source for Sanskrit words like *pippala* (fig), *pippali* (long pepper), *kakkaṭa* (a species of animal), *kukkuṭa* (rooster), and *kukkura* (dog) (Kuiper 1991: 67–68; Witzel 1999: 49). Additionally, a good number of Sanskrit words for sacred and economically valuable Indian plants have Dravidian sources (Bright 1971: 28; Emeneau 1971: 50). These provide compelling grounds for situating the origins of *guggulu/ gulgulu* in a native linguistic milieu. Phonetic correspondences, as is well known, can be dangerously slippery. *Gulgullu*, an Akkadian word for skull attested from the Old Babylonian period on, is, for example, phonetically comparable to *gulgulu* but obviously not related.

More importantly, the geographic origin of *guḫlu* in Mesopotamian texts of the 1st millennium BCE strongly favours a westerly source for this substance. Unlike *bidurḫu*, which will be discussed below, *guḫlu* does not appear to be originating in a Persian Gulf context. The Assyrian king Tukultī-Ninurta II (890–884), receives *guḫlu* as tribute from Ḫindānu on the Middle Euphrates (Grayson 1991: 175, A.0.100.155, line 77). His 7th century BCE counterpart Sennacherib obtains *guḫlu* as tribute from Hezekiah of Judah (Grayson & Novotny 2012: 66 (4.56), 97 (15.iv.5'), 116 (16.iv.28), 133 (17.iii.72) etc.). In the reign of Sennacherib's successor Esarhaddon, *guḫlu* is seized from an Egyptian treasury in Memphis in 671 BCE (Leichty 2011: 192 (103.21)). Meanwhile, Aššurbanipal of Assyria (668–631) imposes a tributary obligation including supplies of *guḫlu* on the Qedarite (north-west Arabian) leader Abī-Yate (Novotny & Jeffers 2018: 77 (3.viii.29), 98 (4.viii 33) etc.). Late 1st millennium BCE medical texts also refer to *guḫlu* from Edom in the Transjordan (Fincke 2009: 93–96; Finkel 2000: 178). *Guḫlu* is attested in at least one easterly context relative to Mesopotamia. The Assyrian king Šamšī-Adad V (823–811) is said to have 'crossed a mountain of *guḫlu*' in his campaign against the Zagrosian polity of Gizilbunda (Grayson 1996: 185, A.0.103.1, col. iii, line 3). Given the broad geographical attestations, it is doubtful if the term, sometimes spelt logographically as NA_4. ŠIM.BI.ZI.DA, even refers to the same substance in all these contexts or if it was semantically broad enough to accommodate a number of related substances. Nathan Wasserman (2015) raises the possibility that there may have been some phonetic conflation when the independently derived Sanskrit *guggulu/ gulgulu* was known to Mesopotamian audiences. In any case, the repeated associations of *guḫlu* with locations west or south-west of Mesopotamia, namely Egypt, Judah, Edom, and Qedar, militates against the notion that the default meaning of *guḫlu* is bdellium.

Finally, the information pertaining to *guḫlu*'s usage in cuneiform sources does not offer a clinching identification with bdellium. All that can be said with certainty is that *guḫlu* was a highly valued substance with ritual and cosmetic uses (Chicago Assyrian Dictionary s.v. *guḫlu*). Esarhaddon uses it, for example, in a foundation deposit ritual at Aššur (Leichty 2011: 126 (57.v.6)). One Neo-Assyrian ritual text includes instructions to smear *guḫlu* (paste) on the eye of a sacrificial animal (Ebeling 1953: no. 79, 12). This sort of usage appears out of place for bdellium. It is also not clear if *guḫlu* is being used as incense in Mesopotamian contexts. The lack of this role would appear puzzling if *guḫlu* is taken to be bdellium,

especially since it is esteemed as incense in the earliest Indian texts. Both Wolfgang Heimpel and Michael Jursa also point out that *guḫlu*, unlike *bidurḫu*, is not used in recipes for aromatic unguents (Heimpel 1987: 58 n. 129; Jursa 2009: 158 n. 51). The precise identity of *guḫlu* and its chemical constituents is beyond the scope of this paper but the long-standing proposal that it is kohl seems most viable (Thompson 1936: 49; Wasserman 2015). This is especially attractive in view of cognate forms in other Semitic languages (e.g. Arabic *kuḥl*, Syriac *kuḥlā* etc.) that invariably refer to a fine paste used for eye make-up and its chemical constituents. It will suffice to say that the *guḫlu-guggulu* connection is a red herring of no further relevance to the history of bdellium in the Persian Gulf and the wider Middle East.

Bdellium in Mesopotamia and beyond

The only word that is etymologically and contextually compatible with bdellium in Akkadian records is *budulḫu* or *bidurḫu*. The first orthographic form is encountered in lexical texts from Assyria in northern Mesopotamia while the latter is the preferred spelling in the Neo-Babylonian dialect of southern Mesopotamia. The use of the ŠIM determinative, which is regularly prefixed to *budulḫu*/ *bidurḫu*, unequivocally indicates that we are dealing with an aromatic substance. More importantly, this word has multiple lexical correspondences in other ancient Middle Eastern and Mediterranean languages (Cohen 2008: 467–470). These include the Hebrew *bᵉdolaḥ*, Phoenician *bdlḥ*, Greek βδέλλιον (var. βδέλλα), and the Latin *bdellium.* Unlike *guḫlu*, the general direction of origin for *budulḫu*/ *bidurḫu* points to the Persian Gulf in the case of Mesopotamian sources while Greco-Roman sources explicitly name Arabia and India as the source of bdellium. The ultimate source of this word remains, however, unclear (Noonan 2019: 73–74). The most historically cogent inference would be that the word was sourced from a non-literate linguistic group in the eastern Arabian region extending from Oman to Bahrain. The variant name for bdellium in modern Jibbali and the Elamite names of the rulers of Bahrain in the 7th century BCE serve as a strong reminder of past linguistic diversity in the Arabian Peninsula (Potts 2006).

The earliest extant appearance of *budulḫu*, albeit in a highly fragmentary context, is in a 12th/ 11th century BCE manuscript of the Uruanna = *maštakal*, a bilingual (Sumerian-Akkadian) list of plants with pharmaceutical applications (Köcher 1955: no. 22 col. iii: 40'f). The colophon of this manuscript, which comes from a library in Aššur, indicates that the text was compiled by 'ten expert physicians' (Böck 2015: 29). *Budulḫu* is subsequently found in Neo-Assyrian (early 1st millennium BCE) copies of lexical texts including the Uruanna = *maštakal* (Köcher 1955: 12 vi 53f; Thompson 1902: pl. 14, line 10) and the Practical Vocabulary of Aššur (Landsberger & Gurney 1957–1958: 329, line 108). The notable absence of *budulḫu* in the earlier lexical tradition of Mesopotamia indicates the novelty of this substance when it first appears in the late 2nd millennium BCE.

None of the lexical texts consulted, thus far, offer any indication of the source of *budulḫu*. Two mid-7th century BCE letters recovered from the Assyrian royal archives in Nineveh are crucial in this regard (Harper 1896: no. 400; 1902: no. 791). This includes the tablet (no. 791) that Potts et al. (1996) had mistakenly identified as a citation for *guḫlu*. The letters dating to c. 646/5 BCE document an exchange between the reigning Assyrian king Aššurbanipal and his general Bēl-ibni who was tasked with bringing order to the Sealand province in the far south of Mesopotamia. This involved the pursuit of the renegade Nabû-bēl-šumāti, a former governor of the Sealand province who had supported Šamaš-šuma-ukīn, king Aššurbanipal's brother, in the preceding civil war (Ito 2018). Nabû-bēl-šumāti held property in Dilmun (Bahrain) where he was briefly backed by the local king Ḫundāru. In the process of confiscating Nabû-bēl-šumāti's property in Dilmun, Bēl-ibni provides Aššurbanipal with an inventory of items in Nabû-bēl-šumāti's possession. It is in this context, we encounter bdellium (*bidurḫu*) in large quantities, presumably sourced from south-eastern Arabia or perhaps even north-western India. The inventory of materials, headed by 176 talents of bdellium (*bi*-[*dur-ḫu*]), included 26 talents of bronze, 9 talents of copper, wool, wooden legs of furniture (*kablu*) and a type of vessel (*inyānu*) among other things (Harper 1902: no. 791 obv. 7–13; de Vaan 1995: 281–282; Frame & Parpola 2023: 103).

As only the determinative ŠIM indicating a class of aromatics and the first sign providing the syllabic value *bi* are preserved on the tablet 791, earlier commentators, including Potts et al. (1996), took this word to be a

logographic reading of *guḫlu*, namely NA_4.ŠIM.BI.ZI.DA (Chicago Assyrian Dictionary s.v. *guḫlu*). This reading is, however, nullified by another letter (Harper 1896: no. 400) that preserves Aššurbanipal's response to Bēl-ibni:

> The king's word to Bēl-ibni: I am well; you can be glad. As to what you said, 'He has entered the sand desert' — you walk under my aegis, do not be afraid. And concerning the bdellium (^{šim}*bi-dur-ḫu*) and the bronze about which you wrote, send it to me; whether little or much, I want to see it. (transl. Parpola 2018: no. 47)

Aššurbanipal's letter to Bēl-ibni, which is in a better state of preservation, confirms that the aromatic material sent by the latter from Dilmun should be restored as the syllabically-spelt ^{šim}*bi-dur-ḫu* (bdellium) and not the logographic form of *guḫlu* (Heimpel 1987: 58–59). These letters confirm a Persian Gulf provenance for bdellium and that Bahrain (ancient Dilmun) functioned as a point of exchange for commodities from the Arabian mainland and/ or South Asia. Bdellium was certainly not travelling in isolation along these routes. The ivory, elephant hides, and timber from species like ebony and *ellūtu* that appear as southern Babylonian tributary materials to the Assyrian court from as early as the 9th century BCE probably came from South Asia via Persian Gulf intermediaries (Muthukumaran 2023: 49). At this point, it is also worth noting that Aššurbanipal's diplomatic contacts encompassed a polity in north-eastern Oman called Qadê, whose king Padê despatched a heavy tribute (*mandattu*) (Novotny & Jeffers 2018: 308 (23.133)). Given that Bēl-ibni's Dilmun inventory included commodities such as woods, metals, and aromatics like bdellium, it is possible that Padê's tribute contained similar items. The town of Izki, which served as the capital of Qadê, was after all located south of the Samā'il gap that separated the western and eastern Hajar mountain ranges on whose rocky slopes *Commiphora wightii* grew (Costa 1988; Potts 1985: 81–83; Schreiber 2004).

Subsequent to the Assyrian period, *budulḫu*/ *bidurḫu* finds mention in a number of cuneiform tablets dating to the Neo-Babylonian and Achaemenid periods (c. 610–331 BCE) (Jursa 2009: 158; Finkel 2000: 188). The bulk of these derive from the voluminous archives of the Ebabbar temple in Sippar and the Eanna temple in Uruk. *Budulḫu* is often found in lists of aromatics (*rīqu*) alongside the likes of myrrh (*murru*), cypress (*šurmēnu*), and cedar (*erēnu*) (e.g. Jursa 1997: 123–124, no. 40; Dougherty 1933: pl. 38 no. 258:1). In one Neo-Babylonian letter from Sippar (c. 555–539 BCE), bdellium is inventoried alongside Indo-Arabian aromatics like myrrh, cassia (*kaṣi'ātu*), and cinnamon (*šalīhātu*) (BM 67001; MacGinnis 1996: no. 16). Another tablet from Sippar dating to the 6th year of Darius I (517/6 BCE) lists *bidurḫu* among several aromatics employed in the production of the fragrant "great oil" (*šamnu rabû*) used in the Ebabbar temple (Jursa 1997: 123–124, no. 40: 12).

From around the mid-1st millennium BCE on, the Akkadian sources are supplemented by a growing body of evidence for bdellium in Hebrew, Greek, and Latin. In the Hebrew Bible, *bᵉdolaḥ*, the equivalent of *budulḫu*/ *bidurḫu*, is associated with an Arabian locality called Havilah (Gen. 2.12; cf. Num. 11.7). A Phoenician inscription on an early 5th century BCE royal sarcophagus from Byblos indicates that its occupant was embalmed with both myrrh (*mr*) and bdellium (*bdlḥ*) (Dixon 2022: 435–436). In the Greek world, knowledge of bdellium was acquired through Alexander's campaigns in South Asia. The Alexander authors do not name the plant but only liken it to myrrh (Strabo XV.2.3). Alexander's companion Aristoboulos observes that the army encountered myrrh trees (σμύρνα) in Gedrosia (Baluchistan) that were larger than the familiar variety (ap. Arrian, *Anab.* 6.22.4). Interestingly, we are then informed that the Phoenician traders who were trailing the army harvested the abundantly available resin. This is not surprising in light of the earlier Phoenician acquaintance with bdellium.

Theophrastus, probably drawing on the writings of the companions of Alexander, describes bdellium as an Indian thorny plant (ἄκανθα) producing resin resembling myrrh (*Hist. pl.* IX.1.2; cf. *Hist. pl.* IV.4.12). There remains a slim possibility that some descriptions of Indian "myrrh" in Greco-Roman sources could correspond with *Boswellia serrata* or Indian frankincense. It is salient to recall that the ancients did not observe a *Boswellia-Commiphora* distinction or have a Linnaean-style taxonomy to begin with. Additionally, most ancient authors did not observe the plant first-hand. While *Boswellia serrata* is reported from Baluchistan, *Commiphora wightii* is better attested in this region so these references can be taken to largely indicate bdellium (Al-Harrasi et al. 2019: 25). In any case, the *Periplus Maris Erythraei* (PME), a Greek merchant-mariner's guide to the Indian Ocean world of

the 1st century CE, observes that bdellium was the most commercially significant product of coastal Baluchistan (PME 37).

By the Hellenistic period, a specific word for bdellium, βδέλλιον, was borrowed into Greek from Semitic sources, indicating a greater familiarity with this substance. Hellenistic physicians like Andreas of Karustos, Apollophanes of Seleukeia, and Bakkheios of Tanagra, all belonging to the late 3rd century BCE, cite bdellium in recipes for compound medicines (ap. Galen, *Comp. Med. Gen.* 7.7 (13.982–983K, 987K); Celsus, *Med.* 5.18.6–7). Greek and Latin authors of the Roman period make clear that bdellium was being sourced from both Arabia and India (e.g. Dioscorides, *Mat. Med.* I.67; Pliny *HN* 12.19 (35–36)). The *Periplus Maris Erythraei* notes that bdellium could be procured at different points along the north-western Indian coast from Baluchistan to Barygaza (PME 37, 39, 48). Galen, who regularly prescribes the use of bdellium in various compound medicines, distinguishes between the Arabian and Scythian varieties of bdellium. The Scythian type is described as darker, more resinous, and moist while the Arabian type is said to be translucent and drier (Galen, *Meth. Med* XIV.4, (10.957K); *Simp. Med.* XI (11.849–851.K)). Scythian in this context should be understood as a vestigial name referring to former Indo-Scythian territories of north-western India and not Central Asia where bdellium is not found (cf. Ptolemy, *Geog.* 7.1.55; PME 38 where the lower Indus region is labelled Scythia).

Epilogue

Overall, it is now amply clear that south-eastern Arabia (modern Oman) was just as important a source of bdellium as north-western India in antiquity. The reference to an "oceanic" variety of bdellium in the *Atharvaveda* indicates that Arabian bdellium may have even reached Indian shores by the early 1st millennium BCE. Indian suppliers of bdellium, drawing on local stocks, emerged as strong competitors to the Arabian incense trade in the Indian Ocean world by the mid- to late-1st millennium BCE. This is apparent from the citation of both India and Arabia as sources for bdellium in Greco-Roman sources. The *Periplus Maris Erythraei*, in fact, inventories bdellium solely as an Indian product.

In the context of the Persian Gulf, sources in Akkadian, the native language of Mesopotamia, establish that the usage of bdellium beyond its native range in south-eastern Arabia can be extended to the last quarter of the 2nd millennium BCE. This paper has also clarified the terminology relating to bdellium in the Akkadian language, establishing that only *budulḫu*/*bidurḫu* can be taken to denote bdellium on linguistic and contextual grounds. The word *guḫlu*, previously thought to be bdellium, shares phonetic similarities with the Sanskrit *guggulu*/*gulgulu* but a close inspection of this linkage reveals it to be a classic case of *faux amis*.

The historical trajectory of bdellium is not unique. Bdellium, alongside other *Commiphora* and *Boswellia* species, became increasingly important in the olfactory landscapes and pharmacological traditions of Afro-Eurasia in the 1st millennium BCE. The regularisation of camel caravanning, the expansion of shipping in the Indian Ocean world, and the rise of stable territorial polities in southern Arabia produced circumstances that were ripe for the long-distance transport of aromatics like frankincense, myrrh, and bdellium. Ritual innovations like cuboid incense altars, changing patterns of olfaction, and widening medical applications for botanical substances also stimulated demand for *Commiphora* and *Boswellia* species. Some like the *Commiphora gileadensis* caught on for a while but were eventually left reeling in the backyard of history while others like *Commiphora wightii* continue to be commercially significant plants.

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The identifications of incenses: lessons learned in the organic analyses in the Mediterranean and the Levant

Elisabeth Dodinet

Summary
Identifying the raw materials used as incense in antiquity for a long time has mostly relied on written sources. However, incenses share several characteristics, which make any identification taunting. Amorphous (at least regarding the resins and the compound materials), they cannot be identified using the standard morphological characteristics only; as luxury and high-priced, sought-after products, they consistently have been exposed to blending, adulteration, and counterfeit. Moreover, their often exotic origin has been associated in trade circuits with legends and mysteries concealing their attributes.
Over the past 30 years, progress within the organic analysis of archaeological residues has shed new light on how to identify these raw materials. Especially within the resins, very often the families and even the genera have become identifiable with the effect of narrowing down the range of possible source materials, sometimes to the extent of challenging established hypotheses. We will present the results of the existing analyses for the Mediterranean area (*sensu lato*, e.g., with its trade circuits) while focusing on the findings from *Boswellia* spp. This transect and broad overview shows that frankincense might not have been the *princeps* incense until today, even though some findings show that it was indeed known and used in the past. The documentation summons us to reflect on the potentially multiple implications of the word 'incense', in line with the pioneering work by Nathalie Baum for the Ptolemaic recipes from the temple at Edfu in Egypt. The ethnobotanical and ethnobiological knowledge needs to be reincorporated into the interpretation of the ancient incense and *per fumere* materials records, to question our Western scientific classifications as a tool for capturing the reality of ancient rituals.

Keywords: *Boswellia,* frankincense, *Pistacia*, organic residue analyses, Mediterranean, Levant, Antiquity, botany, archaeobotany

Introduction

Frankincense (being the product of the *Boswellia* species, Burseraceae) long has been considered the reference incense as from antiquity and later Christianity; it often still is presented as such in the literature. Traditionally, it has been a commodity of east- and westward trade whilst being the main source of wealth for the kingdoms in the Arabian Peninsula, later Eastern Africa, and then of the Arab sea-faring merchants who managed to secure a monopoly on the trade centres. It long remained an exclusive product whose botanical sources were unknown and indistinct and for many centuries remained the object of countless investigations and speculations. Even today, it persists as a taunting subject for botanists and ethnobotanists. Indeed, the products on the market are very hard to trace back to a precise species and location as they often have been mixed or adulterated and sold under a series of loosely employed, local trade names varying from place to place.

For many years, the identification of ancient incense raw materials has been limited to epigraphy and etymological affiliations. However, this approach bears some bias and has often been unable to propose scientifically robust biological attributions (Dodinet 2018). Moreover, all denominations for incense share several characteristics that hinder their correct identification. Being amorphous by nature (when made of resins or crushed compounds), morphological criteria fall short of revealing the resin constituents in archaeological excavations (Fig. 1). Often considered as expensive and luxurious, the product consistently has been susceptible to blending, adulteration, and counterfeit. Originating from far-flung exotic regions, it has been shrouded by mystery and legends, its sources often kept secret by traders. Even today, differentiating the constituent products of incense by eye and describing its different biological ingredients remains problematic (Fig. 2). This was probably also the case in the past so safe identifications cannot be done without chemical analyses.

Figure 1. *A piece of resin retrieved from the Ulu Burun shipwreck. (© Elisabeth Dodinet)*

Over the last 30 years, analytical organic chemistry applied to archaeological artefacts and their residue contents has consisted of identifying some of the used plants through their conserved molecules. These analyses now allow us to identify the organic content of a container at varying degrees of biology ranks, e.g., from the largest to the most accurate, family (often), genus (sometimes), and species (rarely). Analysis of organic residues (hereafter ORA) trapped in archaeological artefacts has since the 1970s been applied to especially identify amorphous residual matter such as resins (for recent reviews, see Evershed 2008; Ribechini et al. 2011; Roffet-Salque et al. 2017; Evershed & Roffet-Salque 2018; Garnier & Dodinet 2021). This field of science aims at identifying the degraded chemical molecules that have survived over centuries and even millennia. The latter are then interpreted through published references or molecular peaks to chemical profiles (chromatograms) obtained from present-day or artificially aged substances. Over time, this has enabled the identification of component classes such as lipids, sugars, and terpenoids..., the latter particularly useful for identifying the incense raw materials. Indeed, resins are characterised by a set of terpenoids of which the main diterpenoids (conifers, and some angiosperm families like the Cistaceae and Fabaceae) and triterpenoids (most angiosperms, or "flowering plants") have been well-preserved. This field is developing fast, although it still is assembling the tools and references to clarify the relevant biomarkers.

Figure 2. *Different resins and incenses from the trade. (© Elisabeth Dodinet)*

The interpretative phase whose aim is to correlate sets of biomarkers with specific plants requires making use of such diverse disciplines as phytochemistry, botany, ethnobotany, and geochemistry, alongside the study of the epigraphic sources whenever available to narrow down the eligible candidates. Despite persisting limitations, as stated by R.P. Evershed (2008: 895) '*as the organic residue field emerges from its pre-paradigmatic phase, and the organic residue revolution gathers pace, the way is open for challenging many long-held archaeological hypotheses and offering new perspectives on the study of human activity in the past.*'

We will present here the status of the existing analyses on the incenses from the Mediterranean at large between the Bronze Age down to late antiquity and the Middle Ages (wherever relevant) to shed light on the fascinating history of '*perfumere*' beyond the epigraphic evidence.

The challenges of identifying frankincense: back to basics

Frankincense, or olibanum, technically is a gum-oleoresin (consisting of three fractions: oil, gum, and resin) produced from various trees of the genus *Boswellia* Roxb. ex Colebr., in the Burseraceae family. The genus was described by Roxburgh, based on the Indian species, *B. serrata* Roxb. ex Colebr., in 1807 only (Colebrooke 1807: 379). Indeed, during the 18th century CE, scholars thought frankincense to be produced from a juniper species, following the view of Linnaeus. The mere existence of Arabian frankincense was still considered uncertain in the mid-19th century (see Thulin 2020: 13–15 for a detailed account of the botanical history of the genus). The Arabian frankincense was first described in 1847, but wrongly attributed to the Indian species. It was acknowledged as a genuinely new species only in 1867 by Friedrich August Flückiger under *B. sacra* Flück.

The genus comprising 24 to 30 accepted species, depending on the botanists, is spread over Africa, the Arabian Peninsula, and India. The phylogeny and taxonomy of some of the species e.g., their biological perimeter, is still debated among researchers (Thulin & Warfa 1987; Weeks, Daly & Simpson 2005; Thulin 2020: 15–16; see also Dodinet 2013 for a synthesis). This is due to a lack of good specimens for study, the wide array of common names, mostly relating to the produced gums rather than the trees themselves, considerable morphological variations within the genus, as well as the challenges related to carrying out fieldwork in some of the countries concerned.

The species *Boswellia sacra* is distributed over Eastern Africa and the Arabian Peninsula (Yemen, Oman). *Boswellia carteri* Birdw., which often appears in the literature as a separate species tapped in antiquity, is now considered by most botanists a synonym of the former, as also another more restricted African one, *B. bhaw-dajiana* Birdw., also sometimes cited. In terms of botanical sources, the three must be considered as a complex (Thulin 2020: 39–40). It is the only species present in the continental Arabian Peninsula.

However, some of the *Boswellia* species endemic to Socotra Island may have entered the trade network as well and been assimilated to the South Arabian sources. *Boswellia socotrana* Balf. f., *B. elongata* Balf. f., and *B. ameero* Balf. f. (Thulin 2001; Miller & Morris 2004; Thulin 2020: 88–93, 94–97, 124–127) are the most frequently reported species as the possible products within the Arabian trade around the turn of the current era (Miller 1969: 104), although the third one is more scattered and in less easily accessible locations. Other species on the island are still tapped today locally under the name of *zama'ano* with various forms used for frankincense resins on Socotra (Thulin 2001; 2020 s.u.). The island is cited in the *Periplus Maris Erythraei* as an important trading place at the turn of the era (69, 30–31).

Two species, *Boswellia serrata* Roxb. ex Colebr. and *B. ovalifoliolata* N.P.Balakr. & A.N.Henry, are strictly endemic to India, although the latter, which has been described only recently, has failed to receive any citation as a source in written reports. The other species spread from Eastern to Western Africa. Most of the ones from the eastern Horn of Africa may have been tapped at some point in antiquity, although the two most cited ones are *B. papyrifera* (Caill. Ex Delile) Hochst. (= *B. occidentalis* Engl.) found in Ethiopia, Eritrea, Sudan, Niger, Northern Nigeria, and Cameroun, as well as *B. frereana* Birdw. (a Somalian endemic). When recorded, the local folk and trade names of the resins, cannot always be matched to a species, a fact widely acknowledged in literature and documented in ethnobotany. Indeed, local designations are rooted in natural cataloguing systems (the often

so-called 'folk categorizations') and are not easily transferable to the current classifications of modern science.

The Burseraceae family and the *Boswellia* genus have the characteristic that when the resin is traditionally collected in mid-summer, the trees are bare, their leaves, flowers, and seeds being transient, and hence not easily identifiable at species level even by expert scholars. Moreover, the harvesting of the resin at all times has been an activity attributed to pastoral nomads, and its mere resinous nature has both now and in the past most likely comprised the tapping of different species growing in close geographical habitats and presenting sufficiently similar qualities (relating to aspect, morphology, scent, and colour). The trade channels only add to this blending aspect which, after the initial harvesting by the mobile collectors, very often passes the resin through the hands of three to five middlemen. At each stage, the wholesalers tend to gather and mix the resins of different origins with poor traceability to the biological and geographical sources (Gebru et al. 2014: 61–62, fig. 2–3; Worku et al. 2011). This was probably also the case in antiquity. Adulteration has also been documented as a current practice today (Jensen 2009; Ingram, Ndumbe & Ewane 2012). This circumstance hinders the referencing of chemical databases that, even for recent works, use trade samples of resins.

The science of incenses: the input from botanical and organic analysis

Frankincense has been widely studied in terms of regional distribution (Thulin & Warfa 1987; Gillett 1991; Thulin 2001; Gebrehiwot et al. 2002; Raffaelli, Mosti & Tardelli 2003; Thulin 2006; 2020: 18–20), resin characteristics, product designation (Morris 1997; Bel & Monod 2001; Bonnet-Chelhi 2002; Gebrehiwot et al. 2003; Lemenih, Abebe & Olsson 2003; Lemenih & Teketay 2003; Farah 2008; Katz 2009; Worku et al. 2011; Worku et al. 2012 *inter alia*), and chemical markers (Basar, Koch & König 2001; Hamm et al. 2003; Basar 2005; Hamm et al. 2005; Assefa et al. 2012; Zhou et al. 2012; Zhang et al. 2013a). More recently, some scholars have studied the markers of the fragrances (Niebler & Buettner 2015a; 2015b) and those of the smoke residues (Baeten et al. 2014). However, as stated above, chemical studies have often relied on traded samples. Moreover, thorough studies associating botany, resin chemistry, and genetics yet need to be carried out on the entire genus to assess the uniqueness of the biomarkers currently proposed at the species level. The resin is furthermore known to vary within a single species, depending on the growth location of the trees (in either elevated or low-lying terrain or environments of varying hygrometry), the harvesting period (between May and October), and the storage conditions after harvesting (from personal observations in Oman and interviews with companies specialised in flavour & fragrance). However, some studies on the Dhofar frankincense have pointed to mostly quantitative differences linked to harvesting periods rather than geographical locations (Ribechini, Rafaelli & Colombini 2008).

At a very early stage, frankincense residue sourced from the *Boswellia* genus has attracted much attention from organic residue analysis. The first markers identified from modern *Boswellia sacra* and some other species resins — α- and β-boswellic acids, whether free or methylated, together with their oxo-derivatives — have proved to preserve over time. Thus, the presence of these markers has been deemed to strongly support the identification at the genus level in archaeological residue analyses (van Bergen et al. 1997; Evershed et al. 1997; Mathe et al. 2004a; Zhou et al. 2012).

At the species level, the identification is still partial. *Boswellia sacra* Flück. (= *Boswellia carterii*; = *B. bhaw-dajiana*), the lead species from the Arabian Peninsula and Eastern Africa (Fig. 3), is considered to be recognised through the presence of boswellic and lupeolic acids (Mathe et al. 2007), although some characteristic diterpenes have also been suggested (Hamm et al. 2005; Colombini & Modugno 2009: 281). The combined presence of lupeolic acid and 3-epi-lupeolic acid has been suggested to indicate a source from *B. frereana* (Mathe et al. 2007: 441 fig. 7, 442), although other studies have challenged these markers in the Somalia-sourced resin of the species (Smiech et al. 2019). It should be noted that this species presents a specific chemical profile since the boswellic acids are either absent or scarcely detectable (Chiavari et al. 1991; Mathe et al. 2004b; Smiech et al. 2019), which could make it difficult to identify in ORA.

The resin of the Indian Boswellia, *B. serrata* Roxb., is considered to be characterised by trucallane and euphane-

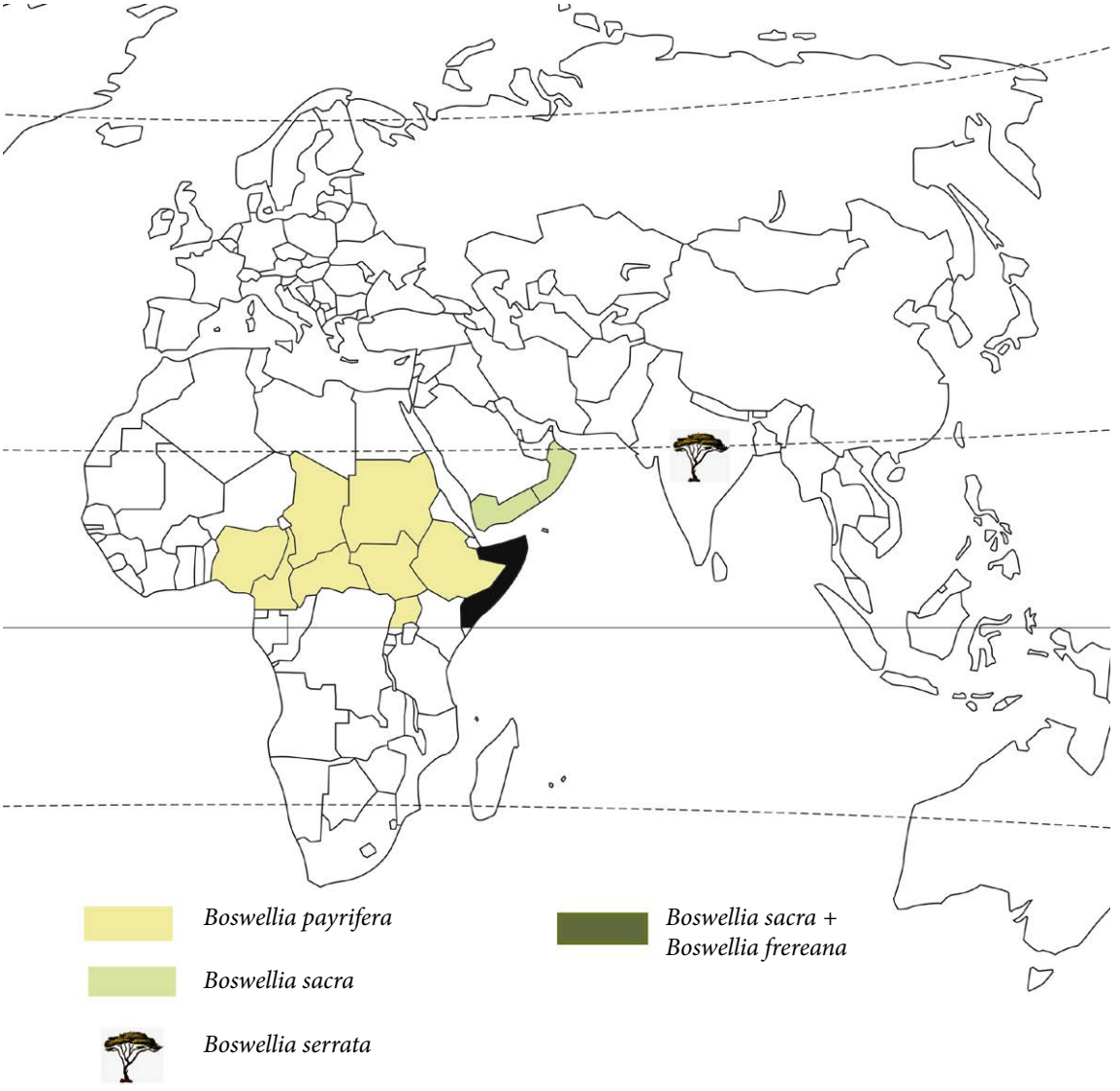

Figure 3. *Distribution of the main Boswellia source species cited in published reports for the identification of frankincense in antiquity. (© Elisabeth Dodinet)*

type skeletons, which would allow to differentiate it from the Arabian-African *Boswellia* sources (Hanuš et al. 2007; Colombini & Modugno 2009: 281). All these need to be taken with caution since many researchers have stressed the doubtful origin of some of their modern samples for referencing (Edwards & Falkes 1997: 2397, 2400; Archier & Vieillescazes 2000: 233 tab. 1, 234; Mathe et al. 2002; Culioli et al. 2003; Bruni & Guglielmi 2014: 615). Others have used trade product references, most probably encompassing several species such as 'trade olibanum Eritrean-type' (Mathe et al. 2004b: 278). Precise chemical signatures of the different species may also reside within the mono- and sesquiterpene fractions, which rarely are preserved in archaeological contexts.

Some Eastern African species are not yet fully characterised in ORA. This is the case for *B. papyrifera*,

which is often claimed to be an ancient source for Eastern Africa. Some markers have been proposed (Colombini & Modugno 2009: 281; Bekana et al. 2014 with the identification of some specific diterpenes, and a comparison with *B. neglecta* S.Moore and *B. rivae* Engl. from Ethiopia), which need to be confirmed over the range of distribution. Minor species such as *B. ogadensis* Vollensen are likewise not well-understood chemically.

Clarifying the situation of the *Boswellia* of Socotra represents an additional scholarly challenge. Extensive archaeological traces of plantations (terraces and enclosure walls) around the locations of *B. socotrana* et *B. elongata* have been retrieved and suggested as testimonies of intensive cultivation around the turn of the current era (Jansen van Rensburg & Hopper 2017; Jansen van Rensburg 2019). The exploitation was most probably linked to the South Arabian kingdoms on the continent (Grant 2005), a fact already acknowledged by Diodorus Siculus (5.42.5) in the 1st century BCE. Their specific diterpene and triterpene signatures have not been published yet, but a thorough study of the genetics and chemical signature of the Socotra species is currently underway at the Royal Botanic Gardens of Edinburgh, as recently presented by J. Jansen van Rensburg and A. Forrest at the Seminar. This is expected to contribute significantly to our knowledge of the early Arabian frankincense trade.

Moreover, the possible chemical differences of the resins within a given species are still poorly understood, although the ethnobotanical sources acknowledge names indicating a differentiation of the products among the collectors. In Somalia, 'mohor madow' (or meddu, black) refers to resin collected in either valleys or lower parts of the hills, 'mohor add' (white) to harvests in higher altitudes (Thulin & Warfa 1987: 491). A similar distinction has been made at a local marketplace in Dhofar in combination with specifications relating to the harvesting period (personal observations).

Overall, the published reports allow us to identify the presence of *Boswellia* resin (at genus level) with a high degree of confidence, except for *B. frereana* (and possibly some other minor species) where the boswellic markers are often absent. However, the attribution to a precise species within the genus needs careful probing while also critically analysing the contemporary references and the literature on which it is based.

An overview of frankincense in the archaeological context

Studies on written and archaeological sources have pointed to occasional procurement sources in Eastern Africa through Egyptian expeditions as early as the Old Kingdom as well as to the establishment of a structured trade network involving the Arabian Peninsula at the beginning of Iron Age II (van Beek 1958; 1960; Asensi-Amorós 2003) or slightly earlier in the Late Bronze Age, 13th–12th c. BCE (Artzy 1994; Jasmin 2005).

To date, the actual discoveries remain scarce and hardly allow for any full confirmation of these hypotheses. The earliest evidence of frankincense has been recovered from an unguent container inside the tomb of Sat-mer-Hout, a twelfth-dynasty princess at Dashur (c. 2200 BCE), where it was found blended with Pinaceae (pine, fir, or cedar) resin (Mathe et al. 2004a; 2005). Compared to the rest of the Eastern Mediterranean, Ancient Egypt is the main region evidencing frankincense from archaeological contexts, as is the case with a Saite period mummy from Saqqarah, ca. 660–526 BCE (Archier & Vieillescazes 2000), and some amorphous pieces retrieved in a cellar at Qasr Ibrim in a late post-Meroitic context, c. 400–700 CE. However, some other samples from the same context were attributed to Pinaceae resins, pointing as suggested by the researchers to their close association with incense-burning ceremonies (Evershed et al. 1997; van Bergen et al. 1997). Frankincense has also been found as wood in Berenikè for the Ptolemaic period (Sidebothan & Zych 2010: 12). Recently, a resin attributed to *Boswellia* sp. was evidenced on a limestone monolith at Arad, Israel, interpreted as an altar dating to the 8th c. BCE through the presence of boswellic acids and norursatriene (Arie, Rosen & Namdar 2020)[1] together with indications of animal fats.

On the Arabian Peninsula, it has been evidenced at Qâni', a 1st century CE site in Yemen (Mathe et al. 2007; Connan, Joliot & Mathe 2018) and in limestone incense burners from a residential quarter of Tayma, an oasis along the incense road in northern Saudi Arabia, as also myrrh (from *Commiphora* sp., Burseraceae) in conical incense

[1] The publication puts forward a combination of frankincense and *Cannabis* sp.; the analysis of the chemical findings confirms the presence of *Boswellia*. The elements on which the authors propose the *Cannabis* interpretation are more debatable.

burners in a graveyard. *Pistacia* sp. resin (Anacardiaceae) was also identified at the same site in small goblets used as incense burners inside a large architectural complex (Huber et al. 2018a; 2018b; this volume).

In Europe, it was recorded in funerary contexts in Rome dated to the 3rd century CE (Devièze et al. 2017) and as embalming material in a Christian tomb, though probably in the form of wood rather than resin. Finds in the United Kingdom include several mummification unguents (1st to 2nd century CE) and at Mersea Island Barrow associated with a cremated bone, together with a conifer resin (Brettell, Stern & Heron 2013; Brettell et al. 2013; 2015).

Altogether, the evidence seems to concentrate to the end of Antiquity and is not strictly associated with an 'incense' function. However, it needs to be noted that yet very few incense burners have undergone organic analysis, which possibly induces a record bias. The findings from Tayma seem to point to a local chronology of incense burning of *Pistacia* resin in Early Iron Age contexts (12th to 9th c. BCE), myrrh between the 9th and 5th c. BCE, and *Boswellia* between the 2nd half of the 1st millennium BCE and the early Byzantine period. The chronological framework remains nonetheless sketchy, as it is associated with the built structures and not the analysed objects.

In later contexts, frankincense furthermore occurs in fumigation cups from Tours (Garnier et al. 2013). *Boswellia* resin with juniper (*Juniperus* sp., Cupressaceae) and possibly pine tar has also been identified in perforated pots used as incense burners in southern Belgian graves of the 11th–12th c. CE (Baeten et al. 2014). These finds confirm the use of frankincense in Catholic rituals in Europe, although they (sometimes? often?) occur mixed with other resins. It has also been documented in embalming processes (Charlier et al. 2013).

Some intriguing discoveries challenge the status of frankincense as the reference incense

At Sumhuram/Khor el Rori (identified as the Roman emporium of Moscha Limen, 1st c. CE), a residue recorded in a round, tripod incense burner was identified as a Pinaceae (from the pine, cedar, and fir family) resin (Ribechini & Colombini 2008). Four Nabatean specimens from Hegra were most probably revealed to be *Canarium* sp. (white mahogany, elemi), an African genus in the Burseraceae family (Mathe et al. 2009). In a Nabatean alabaster lid found in the Aravah valley, Israel, the resinous concretion was identified as pine tar and a plant-based lipidic material, probably oil (Hanuš & Ben-Yehoshua 2013). Although this may have been a sealant material, the authors stress that pine resin, tar, and pitch are indeed described in ancient written sources as medicinal components and balms. The findings at Tayma (Huber et al. this volume), which is located within the core area of the frankincense network, are challenging as well.

In Egypt, recent analyses have been carried out on several artefacts containing embalming substances that were recovered from a cache at Saqqara dating to the 26th dynasty (664–525 BCE), some of which with inscriptions mentioning the materials 'sefet' and 'dry antyu'. These probes similarly identified Cupressaceae (juniper/cypress) oil or tar, cedar oil or tar, *Pistacia* resin, *Canarium* sp., one of the old-world sources of elemi, and a dammar (Dipterocarpaceae) resin (Rageot et al. 2022). In some vessels with the label 'antyu' the authors identified markers of a mixture of coniferous volatile products and fat, not myrrh as had been suggested lexicographically by scholars (Rageot et al. 2022: 6 and extended data fig. 1).

Interestingly, none of the analyses on the foundation deposits of the temple of Hatshepsut, who was famous for her expeditions to the land of Punt, the region from where Ancient Egypt imported 'senetjer' and 'antyu', yielded frankincense or for that matter *Commiphora* sp. resin. The identified resins rather corresponded with the styrax-type, from *Styrax officinalis* L., Styracaceae or *Liquidambar orientalis* Mill., Hamamelidaceae, or resins from *Pistacia* sp. (Serpico 2011: 852, table 1).

For the medieval site at Sharma which the written sources identify as one of the main ports of the incense trade, the analyses showed that 84% of the studied resinous materials originated actually from legume family trees, most probably *Hymenaea* spp., that grow in Madagascar and East Africa, whilst only two samples turned out to be frankincense (Regert et al. 2008a; 2008b; 2015). Similarly, an analysis of the residue of an East African incense burner from Zanzibar (Tanzania) dating to the 7–8th c. CE, identified the material to be from a

local source of the legume family, *Hymenaea verrucosa* Gaertn., (Crowther et al. 2015).

Pistacia sp., the Bronze Age reference incense, and a resource still used in the Iron and Roman ages?

Most of the resinous materials analysed so far, including those from the Egyptian 'senetjer' jars, were attributed by ORA to the genus *Pistacia,* Anacardiaceae (Stern et al. 2003).

Three main resin-producing species are known from the Mediterranean and the Levantine region: *P. atlantica* Desf. (Persian turpentine tree, whose habitats extend from the southern and eastern Mediterranean to the central Himalayas), *P. lentiscus* L. (mastic, a strictly Mediterranean species), and *P. terebinthus* L. (turpentine, which is distributed through the Mediterranean and the Levant).[2] However, two other species, *Pistacia khinjuk* Stocks and *Pistacia falcata* Becc. ex Martelli grow in the Arabian Peninsula and parts of Egypt and Eastern Africa, and may thus have been sourced along the trade routes. Although it does not seem to produce resin, *P. khinju*k is locally considered in Al'Ulah as a 'bakhour' for the pleasant scent of its wood when burned (unpublished, personal data).

The markers of the genus are known, including for aged and heated resins, and are always detectable with ORA (Stern et al. 2003). Although the aged markers in triterpenes at the species level yet remain poorly determined, isotopic signatures may allow such identifications in future (Stern et al. 2008). Currently, neither the mastic (*P. lentiscus* L. var. *Chia*), nor lentisk resin (from other *P. lentiscus*), can be differentiated from turpentine (*P. terebinthus*), nor can the Mediterranean sources of turpentine (*P. terebinthus*), or mastic, be separated from those of the Irano-Turanian (*P. atlantica*, *P. khinjuk*) or Arabo-African regions (*P. falcata, P. khinjuk*).

Pistacia resin has been identified as early as the Neolithic in Greece (Marangou & Stern 2009), the Early Bronze Age together with figs in Egyptian wine jars at Abydos (1st dynasty) (McGovern et al. 1997), and associated with myrrh in an unguent container inside a tomb at Dashur, dating to the 12th dynasty (Middle Kingdom) (Vieillescazes & Coen 1993). Its use in perfume may also be inferred from finds in Minoan Crete at Pseira (2nd millennium BCE) and a conical cup at Apodoulou in Middle Minoan II contexts (Beck et al. 2008). It has been identified in several contexts of mummification in Egypt (see Stern et al. 2018 for a review).

The genus has been well documented by palynology, dendrology, anthracology, and carpology throughout the Levant and the Mediterranean Basin as from the Neolithic (Willcox 1991).

More importantly, at the Late Bronze Age site of El Amarna in Egypt, *Pistacia* sp. resin has been identified in a Canaanite amphora of Levantine origin tagged as 'senetjer' and also on sherds displaying scorch marks (Serpico & White 1998; Serpico et al. 2003; Stern et al. 2003), and possibly at Karnak as well for the New Kingdom (Le Fur 1994). This resin was a special commodity, as also revealed by the large quantities contained in the Canaanite amphorae retrieved from the Late Bronze Age (14th c. BCE) Ulu Burun shipwreck (Mills & White 1989; Pulak 2001; Stern et al. 2018). *Pistacia* resin probably used as incense has furthermore been identified on New Kingdom ceramic sherds from Sai Island, Nubia (18th dynasty;1548–1302 BCE) (Fulcher & Budka 2020).

In the case of the Ulu Burun wreck, the combined presence of a rare and a more common snail species inside the amphorae led to limiting the provenance of the resin to an area near the Dead Sea (Welter-Schultes 2008), with *P. atlantica* as the most likely source since it is the dominant species of the genus in this area. For the 'senetjer' sources of Late Bronze Age Egypt, an interesting transversal work on the Canaanite amphorae used for the *Pistacia* resin (Smith et al. 2004) showed that the amphorae originated from two distinct regions, which incited the authors to also propose *P. terebinthus* as one of the possible sources. This shows the interest in combining several disciplines to promote the interpretation of the results of ORA.

Pistacia still appears in the analyses regarding the Roman (Colombini et al. 2005; Bruni & Guglielmi 2014) and the Coptic periods (Modugno, Ribechini & Colombini 2006a; 2006b), as in the case of a ceramic censer (5th–7th c. CE) together with a Styrax-type resin, a vegetable oil

[2] Although the database 'Plants of the World online' (https://powo.science.kew.org/) marks the presence of *P. atlantica* and *P. terebinthus* in Egypt, Eastern Africa and the Arabian Peninsula, the records are doubtful and so far remain unconfirmed in botanical explorations and publications (Miller, Cope & Nyberg 1996; Chaudhary 2001; Boutros 1999–2005; Thulin 1999, among *alia*). Another species, *P. aethiopica*, is found in Yemen, although it is rare (S. Neale, personal communication).

from Brassicaceae, and a Pinaceae resin. *Pistacia* resin, initially thought to be frankincense was also identified in the 'lady of the sarcophagus' in the necropolis of the Università Cattolica in Milan dated to the first half of the 3rd century CE (Bruni & Guglielmi 2014: 615, 617).

Overall, the archaeological finds of *Pistacia* resin as incense and a precious raw material commodity are significant throughout much of antiquity and widespread in terms of geography.

Discussion: 'incense', a multiple trade product in antiquity?

The botanical sources of incense in antiquity as so far evidenced by the organic residue analyses appear to have been diverse, even along the Arabian trade routes (Fig. 4). They call for some observations that may generate new perspectives of research.

Resins from *Pistacia* species appear to have been used earlier than frankincense, whose procurement was probably highly sporadic before the Iron Age. The former continued to be used alongside *Boswellia* sources even after the incense trade routes warranted a more regular supply; in fact, the frankincense supply may have been scanty before the Roman era. This leads to suggest that either some native species of *Pistacia* were tapped by the Arabian traders or that resources from the Mediterranean and Irano-Turanian region were circulating, possibly on the return way of Arabian routes. Interestingly, in the 19th century, the two genera were grouped by botanists into a single family, the Terebinthaceae, because they presented some olfactive similarities, which may explain why they were traded and used together. Nathalie Baum has suggested that the resin of *Pistacia terebinthus* could be the viscous 'senetjer' and the 'senetjer saq' in some Ptolemaic lists (Baum 2003: 19). The hypothesis that 'senetjer' represents a resin of *Pistacia terebinthus* or even *P. kinjhuk* had already been advanced by Victor Loret (1952: 15ss; 1954: § 30).

The discovery of the Mediterranean and Levantine Styrax-type resin in the foundation deposits of the temple of Hatshepsut as well as the use of *Pistacia* resin point to a north-south oriented trade network for incense raw materials. This may also be inferred from one of the inscriptions on the South Arabian cubic incense burners that served for burning a material designated as '*ldn*' (*lādan*) and interpreted as the la(b) danum, the resin of the Mediterranean *Cistus* spp., Cistaceae (Robin 1994: 27).

The presence of other sources such as *Canarium* sp. and *Hymenaea* sp. in the core area of the trade network points to strictly African resources from different genera within the Burseraceae (for *Canarium*) and even different families, *Hymenaea* being a Fabaceae (e.g., the Legume family), being tapped and circulating along the Arabian routes. Given the find locations, this indicates that significantly different raw materials contributed to this trade and were all at the time considered as incense.

The tapping of African sources suggests that *Boswellia* not native to the Arabian Peninsula most probably also entered the trade, just like the Indian one later on. Thus, an in-depth study of the diagnostic terpenes of the different species is needed to secure robust specific signatures for each species. This, together with the knowledge of the expected signatures for the Socotra *Boswellia* , would allow future analyses to better discriminate between provenances and between trade networks. As indicated above, all available ethnobotanical studies show that the differentiations in the local designations and trade names refer to areas of growth (e.g. referring to elevation), or else to visual features (large white lumps versus smaller, powdery, or darker ones, or levels of purity) rather than species. This may also have been the case in the past. For this matter, *Boswellia frereana*, which is sometimes cited as a source as it is considered the best quality resin of the current frankincense trade, can be excluded from the category. Its resin is distinguished from other *Boswellia* by the absence of boswellic acids and a strong presence of limonene, generating a lemony sweet perfume quite different to that of the other species of *Boswellia*. Although the tree often occurs together with *B. sacra* in Eastern Africa, it is unlikely that it was traded under the same category; thus, if it had been tapped and traded in antiquity, it would have had a different name.

Moreover, the raw materials used in the region may have comprised some exotic sources from Asia as early as the middle of the 1st millennium BCE. Two recent ORA findings have demonstrated this, both linked to embalming materials in Egypt. An Asian Dipterocarapaceae resin (dammar resin) has been suggested at Saqqara in connection with one 26th

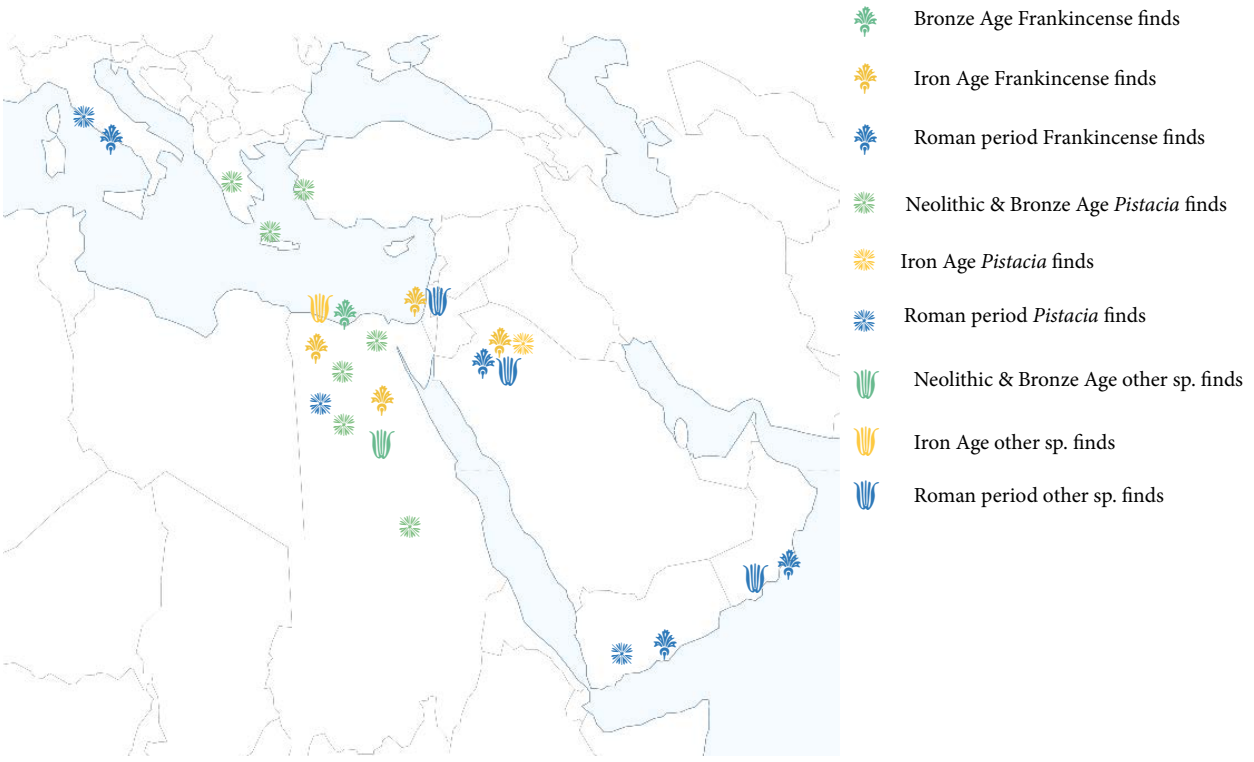
Bronze Age Frankincense finds
Iron Age Frankincense finds
Roman period Frankincense finds
Neolithic & Bronze Age *Pistacia* finds
Iron Age *Pistacia* finds
Roman period *Pistacia* finds
Neolithic & Bronze Age other sp. finds
Iron Age other sp. finds
Roman period other sp. finds

Figure 4. *Find distribution of ancient resins confirmed by archaeological analyses. (© Elisabeth Dodinet)*

dynasty (664–625 BCE) red bowl (Rageot et al. 2022). A second finding also pointing to a Dipterocarpaceae signature was documented within a mummification balm of the 18th dynasty, based on dammarenolic acid compound. The authors acknowledge that, although this compound naturally occurs in dammar resin, it may also represent an oxidation product of dammaradienone, a compound contained in *Pistacia* resin. They thus stress that 'the two cannot be unambiguously differentiated in the current state of knowledge' (Huber et al. 2023). Indeed, identifying the other diagnostic compounds of Dipterocarpaceae is required for a better distinction from *Pistacia* sp. resins before expounding any steadfast hypothesis of long-distance trade for this early period.

In the light of these findings, the perimeter of the words translated as 'incense' or often 'frankincense', needs to be probed into. In English, the word frankincense designating the incense of the *Boswellia* species, was formed as meaning the true incense ('*franc encens*'), which indeed pointed to a larger incense category. Similarly, when benzoin was introduced to Europe around the 15th century, it was negotiated under the name of '*luban jawi*' (the 'frankincense' of Java), which served by derivation to forge its current name ('benjouin' in French), thus evoking that it was traded by merchants as an incense sub-category.

Today, the word 'incense' refers to a large category of products, whether compound or from single raw materials, destined for incineration in different shapes consisting of sticks, cones, powders, spheroids, resins, etc. This may have also been the case in the past. At least some of the designations used in different civilisations may indeed have been portmanteau words describing large pre-scientific categories, covering

various botanical genera and families. They hence cannot be seen as designations for frankincense based on etymological affiliations unless they are confirmed by hard evidence. Thought should be given to the possibility that the shared category-defining characteristics may have been limited to certain periods, social groups, or geographical areas. The 'incense group' may indeed have been defined by colour (white, yellow), shape (drop-like), consistency (hardness), or scent, or function be it to please the gods or prophylactically repel night-time miasmas. Certain material characteristics may furthermore have nourished symbolic connotations, such as exudation processes (in the form of teardrops deemed as male), or associations to certain origins, thus bestowing the incense with ritual significance, or still, mere rarity or exotism to enhance the prestige of the donor. In this case, the selection among the biological specimens would have been determined by the desired attributes. The product's origin for instance from the Land of Punt (the Land of God) may have conveyed specific such symbolic connotations in Pharaonic Egypt.

The incense concept thus incorporates two broad dimensions, one being biological and the other social. The process by which a given species or group of species at a given time in a specific geographical area is attributed the purpose of serving as incense needs further investigation. This may consist of a biological pre-adaptation, like the specific characteristics of resins that need to be burnt to reveal their fragrances or oozing capacities (e.g. schizogenous olea-gum-resin pockets), or else be the result of social implications. Thus, the perimeter of any designation may have varied significantly over time depending on place and civilisation. Ethnobotany has documented such shifts in category contents used by various human groups to organise and name the plants in their respective environments and to describe their processes of formation (see for instance Berlin et al. 1973; Katz 1994; Grenand 1995). We may assume that such processes and logic have been at work in all pre-scientific human groups but that the texts often do not allow their proper decipherment. Indeed, before Theophrastus, Dioscorides and Pliny the Elder, we have very few precise descriptions of the botanical sources involved, except sometimes their geographical origins or their trade routes. The few representations of the sourced trees are codified and do not permit proper identification. In the few instances that written evidence does exist, as in the case of the Ptolemaic temple at Edfu, careful study has shown that the so-called 'myrrh' and 'incense' products ('antyu' and 'senetjer') comprised many different sources belonging to various botanical genera and families (Baum 1999; 2003).

Conclusion

The findings presented by ORA furnish some insight as to the use of frankincense in the Bronze Age by confirming its occasional use but so far not as incense, whilst revealing that *Pistacia* resins may have been the reference incense, especially in the Late Bronze Age, a period in which international trade has been verified on a large-scale by the evidence furnished at the Ulu Burun shipwreck.

The picture for the Iron Age is still unclear, as relevant analyses have only been carried out on very few incense burners to date. An increase in the use of frankincense can be confirmed for the second half of the 1st millennium BCE, especially during the Roman period. However, the evidence for the *Pistacia* resin seems to persist and new biological sources from *Canarium* and *Hymenaea* genera begin to appear at the very centre of the land of frankincense, parallel to frankincense. Pine resin is also evidenced and possibly a styrax-type resin from *Styrax officinalis* L., Styracaceae or *Liquidambar orientalis* Mill., Altingiaceae in compound recipes. The trade routes may thus have been more complex than just main south-north traffic dedicated to frankincense, and the question concerning the raw materials circulating back from north to south needs to be addressed as well.

Overall a program for sampling and analysing incense burners from different periods and contexts is urgently required to strengthen the picture of incense materials in antiquity.

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Exploring the aromatic diversity of incense materials at the ancient oasis of Taymāʾ using metabolic profiling

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Summary
The burning of aromatics is deeply woven into Arabian culture, closely tied to the history of the thriving aromatics trade along the Incense Road. While frankincense played a significant role in the story of this trade, it represents just a fraction of the olfactory landscape of ancient Arabia. This chapter investigates the aromatic diversity at the ancient oasis of Taymāʾ, unveiling the complexity of sensory experience at this important hub on the Incense Road. Employing metabolic profiling through GC-MS and LC-MS/MS techniques, we unravel the biomolecular composition of these ancient substances, shedding light on a broad range of aromatics with distinct applications over time. The results underscore the pivotal role of olfactory elements in shaping both cultural and economic dimensions of human life, influencing rituals, practices, and daily life at Taymāʾ and beyond. Our findings provide a more comprehensive picture of the impact of the burning and consumption of aromatics on local and regional landscape uses in the heart of the Arabian Peninsula.

Keywords: Ancient Arabia, biomolecular archaeology, metabolic profiling, olfactory culture, aromatics

Introduction

Common perceptions of ancient cultures in Arabia often evoke the burning of incense and the movement of aromatic substances along ancient trade routes, such as the Incense Road (Groom 1981). This connection stems from the central role these aromatics played in religious, cultural, and commercial exchanges in the past, as well as from the shared history of their use by different groups and societies on the Arabian Peninsula (Baird 2021). Some of these traditions continue to this day, with incense burners acting as a material manifestation of this legacy. The burners remain popular items in homes and places of worship, and have significantly contributed to shaping local identities and collective practices over time. In the past, incense smells were used for a variety of reasons, including ritual ceremonies, to mask malodors, and to provide a pleasant fragrance (cf. Theophrastus, *De Odoribus*; for the Greek Classical period). Incense was also believed to have healing, purifying and disinfecting properties, and was applied for personal hygiene purposes, as well as to protect against diseases and to repel pests (cf. Celsus, *De Medicina*; Dioscorides, *Materia Medica* for the Roman imperial period).

Among the incense scents of ancient Arabia, frankincense was one of the most iconic (Zimmerle 2021). This scent-intensive resin was obtained from wild shrub-like *Boswellia* trees by tapping into the bark of the trees to produce exuded gum resin. Frankincense played an important role in Arabia's economy and was a key commodity of the aromatics trade in the 1st millennium BCE (Avanzini 1997; Singer 2007; Bar-Oz et al. 2022). The fragrant qualities of frankincense and other aromatics were highly desired by the elites of neighboring and distant regions, particularly ancient Egypt, Mesopotamia, Anatolia, Greece, and Rome (Serpico & White 2000; Haas 2003; Leichty 2011). According to Pliny the Elder, incense, and especially frankincense, was burned on a lavish scale by certain Roman Emperors (Plinius, *Naturalis Historia* XII.41, 82–84), and also Neo-Assyrian kings such as Esarhaddon and Tiglath-Pileser III obtained vast quantities of Arabian aromatics (Leichty 2011; see Neumann, this volume),

demonstrating the high demand for these substances and the large amounts that were being transported. In the Hittite cultural realm of central Anatolia, a variety of substances beyond resin and wood were burned in magic and medical ritual contexts (Haas 2003).

However, frankincense was not the sole aromatic of cultural and economic significance in ancient Arabia. The olfactory landscape of Arabia was varied, witnessing the introduction and use of a number of different aromatic substances, ranging from resins to balsams, scented woods, herbs, oils, and spices (Regert et al. 2008; Mathe et al. 2009). For instance, 1st millennium BCE South Arabian incense burners bear Sabaic inscriptions that can be interpreted as referring to aromatic substances (Biella 1982; Nebes 2014). The inscriptions reveal the words *qsṭ* (likely Indian costus, an aromatic root), *rndm* (nard, an essential oil used as a perfume or incense), as well as the words *kmkm* and *ldn*, associated with aromatic resins[1] (Biella 1982). Additional inscriptions on incense burners include aromatic names like *lbny* (possibly referring to frankincense or styrax) (Zimmerle 2021). These aromatics encompassed a broad range of commodities including cosmetics, medicines, food flavourings, and products for sanitation and disinfection as well as ritual practices.

Although the Sabaic sources mention a variety of names for aromatic substances, accurately translating these plant names continues to be a challenge, as exemplified above. Accordingly, most of these names can only be tentatively translated. In general, ancient written sources, especially cuneiform and Egyptian texts, provide limited information on the exact botanical source of aromatic substances, making precise identification of the type of incense material used difficult (Germer 2008; Böck 2011; Geller & Panayotov 2018; Haas 2003).[2] This is due to the fact that identifications of plants from ancient texts are mostly based on epigraphic studies and ethno-comparisons, both of which can be misleading (Panayotov 2014; Pommerening 2016). Furthermore, vernacular nomenclature, especially for plants, is dynamic and, when transferred through languages, sometimes shifts meaning, or changes entirely over time and across regions (Scurlock 2012). As a result, although ancient texts provide valuable insights into the cultural perception and use of aromatics and smells, they often lack specificity regarding the actual aromatic substances used. Tangible evidence of aromatics in archaeobotanical assemblages is also rare, as burnt incense products leave almost no macroscopic traces (Scott et al. 2020; see Dodinet, this volume). Yet, taxon identification is critical for effectively studying ancient trade and for tracing the origins of scented substances. Thus, the limitations of textual and archaeobotanical sources necessitate the use of complementary approaches for a more accurate reconstruction of the aromatic plants used (cf. Hepper 1987; 1992).

Modern analytical methods have the potential to help overcome long-term challenges in identifying ancient aromatic substances (Huber et al. 2022a). Biochemical and biomolecular analyses can be employed in archaeology to explore and identify organic residues from archaeological artefacts. These analyses allow us to discern between different aromatics and give us hints as to how these plants were further processed (see, most recently, Huber & Luciani et al. 2025). One way to target past use of aromatics is to specifically sample archaeological artefacts associated with the use of fragrant substances, such as incense burners. Traces of the burned aromatics can survive as residual crusts on object surfaces and even as 'invisible residues', which are absorbed by the porous matrix of the incense burner material (Evershed 2008; Roffet-Salque et al. 2017). However, to date, the majority of chemical analyses of organic residues have been done on food-related vessels and jars for unguents and medical remedies as well as on mummies rather than incense burners. Moreover, these analyses have mostly concerned ancient Egypt and Classical Antiquity (Colombini et al. 2005; Charrié-Duhaut et al. 2007; Dunne et al. 2012; Giachi et al. 2013; Brettell et al. 2017; Evershed & Clark 2020; Huber et al. 2023). As a result, in Arabia, analytical studies of organic residues remain relatively rare.

In this paper, we study the diversity of aromatics used at the ancient oasis of Taymāʾ, a large north-western Arabian settlement dating from the Early Bronze

[1] The Sabaic Online Dictionary of the Friedrich-Schiller Universität Jena has been used for translations of Sabaic names: http://sabaweb.uni-jena.de/Sabaweb/Suche/Suche; accessed on 16.10.2023; further online resources are the Digital Archive for the Study of Pre-Islamic Arabian Inscriptions (DASI), https://dasi.cnr.it/; last access 24.03.2024, and the OCIANA Database (Online Corpus of the Inscriptions in Ancient North Arabia, https://ociana.osu.edu/, accessed on 14.10.2024). The PhD dissertation of Robert Stähle (University of Jena, 2022) on ancient South-Arabian altars has not yet been published.

[2] For the challenges in accurately identifying Akkadian terms, cf. Muthukumaran, this volume.

Age onwards, through metabolic profiling of organic remains preserved within incense burners. Located on a branch of the Incense Road in an arid landscape, the oasis was a major hub of the caravan trade (Macdonald 1997; Hausleiter & Eichmann 2018; Hausleiter 2019) and an important intersection between southern parts of the Arabian Peninsula, Egypt, the Levant, Assyria, and Babylonia, as well as eastern Arabia and the Gulf (Hausleiter 2012), connecting producers and consumers of aromatics. Over the course of excavations at the site, numerous incense burners were discovered showing both traces of burning and residues of resinous substances on the interior (Huber et al. 2018; Huber 2020). Applying a multi-analytical approach, including gas chromatography mass spectrometry (GC-MS) and liquid chromatography tandem mass spectrometry (LC-MS/MS), we analyzed amorphous visible residues and remains absorbed by the materials from these objects and interpreted them within the archaeological and palaeoenvironmental contexts of the site. These traces yielded an extensive dataset for discussing aromatic diversity, trade, consumption, and the use of scented products in the Arabian Peninsula.

Archaeological contexts and uses of incense burners at the oasis of Taymāʾ

Evidence of grape pollen, consistently recorded since around 4500 calBCE (6500 calBP) marks the onset of oasis cultivation at Taymāʾ.[3] A permanent settlement emerged at the site during the late 4th millennium BCE, established by a pottery-producing community (Fig. 1; Hausleiter 2019; Tourtet, Daszkiewicz & Hausleiter 2021).[4] Within a short period, the oasis grew to more than 9 square kilometres. The construction of a substantial wall enclosure around the oasis in the early 3rd millennium BCE (Hausleiter 2018) facilitated the establishment of a significant settlement area alongside extensive agricultural zones. From the Early Iron Age onwards, archaeological evidence reveals the development of a large irrigation system, including several canals, basins, and wells to supply the subsistence economy of the southern part of the oasis with groundwater (Hausleiter & Eichmann 2018).[5] The oasis was then permanently occupied over several millennia until modern times. Archaeometallurgical studies of objects found at Taymāʾ demonstrate long-distance contacts dating back to the late 3rd / early 2nd millennium BCE. These findings suggest a dynamic metal trade network on the Arabian Peninsula during these times, extending towards the Levant and the Omani peninsula in subsequent periods (Höppner, Lockhoff & Pernicka 2011; Hausleiter, D'Andrea & Zur 2018; cf., Liu et al. 2015: 499; Renzi et al. 2016).

Evidence for the use of incense at the oasis of Taymāʾ is present in various archaeological contexts both within and beyond the enclosed oasis: in public buildings, such as temples, in dwellings and storage rooms within the domestic quarter, and in tombs in the cemeteries to the south of the settlement (Huber et al. 2018; Huber 2020). From a chronological point of view, the earliest evidence for the burning of incense at Taymāʾ stems from the Middle Bronze Age (1st half of the 2nd millennium BCE), with the continued presence of incense burners until late antiquity (Fig. 2). The two oldest incense burners at Taymāʾ date to the Middle Bronze Age and come from different contexts within the settlement (Huber 2020). The first one was found within a tower (W41-b1) next to the western branch of the oasis wall, whose two building stages can be dated to the end of the first / beginning of the second half of the 2nd millennium BCE (Hausleiter 2014; Sperveslage 2018). The context of the second burner remains unclear, as it was found in a secondary context, where it had been redeposited at a later date. The burners are made from coarse clay bearing mineral inclusions and coated with a dark reddish slip, which was subsequently burnished. These characteristics classify them as Red Burnished Ware (Fig. 6, line 1; Tourtet, Daszkiewicz & Hausleiter 2021; Huber 2020: fig. 3).

Incense burners have also been found in other public contexts at Taymāʾ, notably within a large Early Iron Age complex comprising a main temple building (O-b1) and several adjacent rooms (Intilia 2011; 2012;

[3] This date is based on most recent evaluation of analytical data (cf., previously, Dinies et al. 2016; Hausleiter & Eichmann 2018; Hausleiter 2019 referring to slightly older dates).

[4] The oldest human presence at the site can be dated to the late 7th / early 6th millennium BCE (Late Neolithic) as indicated by flint tools (Purschwitz 2017).

[5] For possible remains of an irrigation system of older date in the eastern part of the sabkha, cf. Hausleiter 2018; irrigation channels in the center of the present-day oasis are associated with Early-to-Middle-Bronze Age pottery sherds (Red Burnished Ware); M. Alonazi, M. Haibt, J. Schönicke, personal communication.

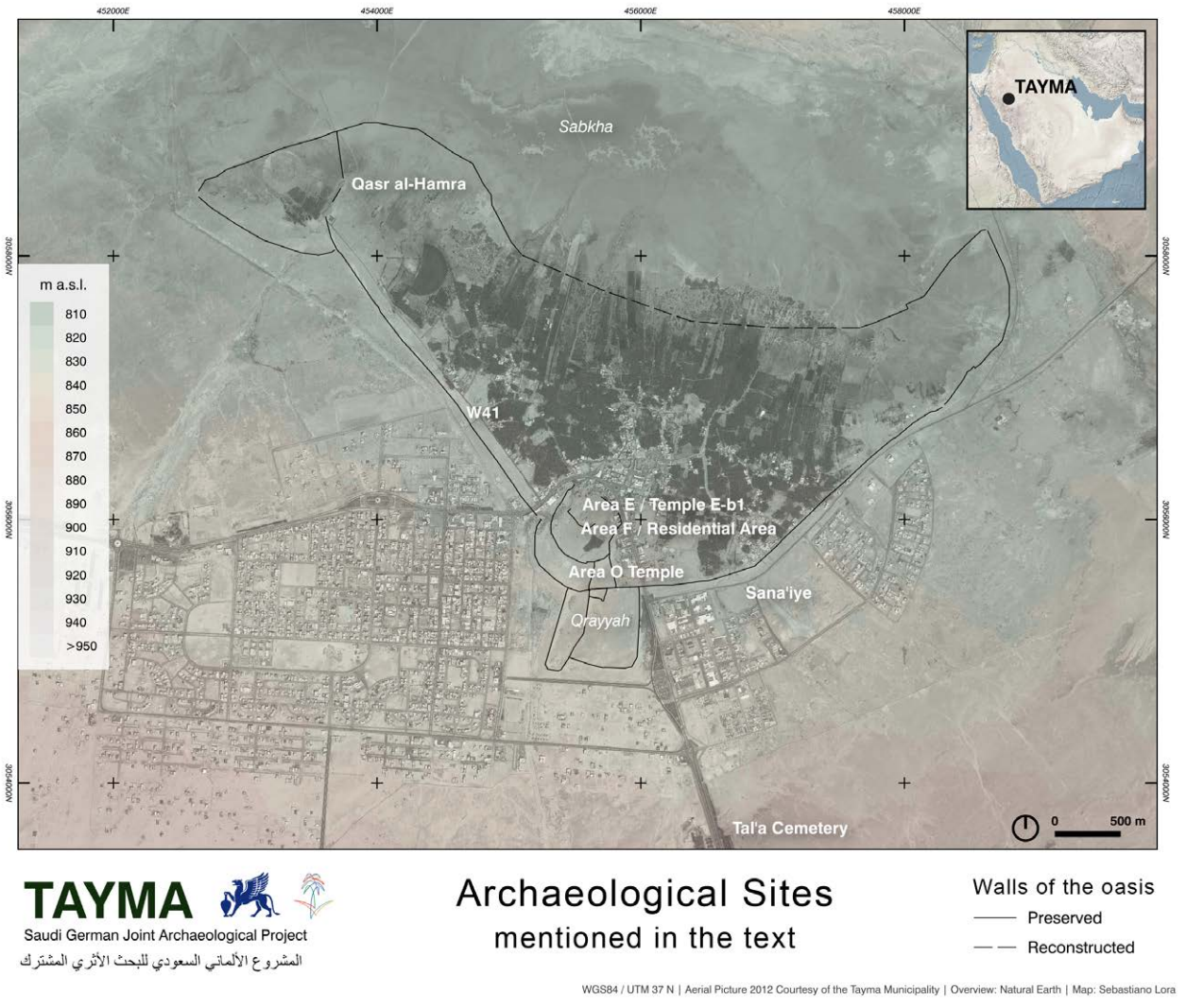
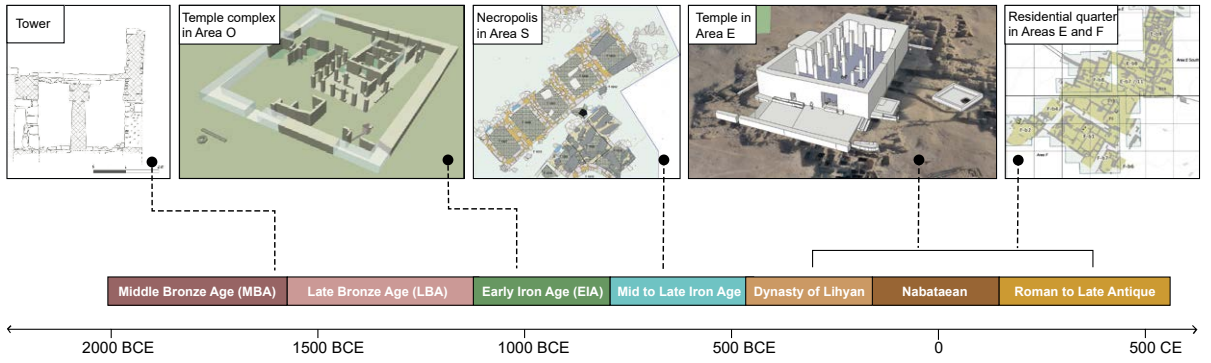


Figure 1. *The oasis settlement of Taymāʾ (map: DAI Orient Department, Sebastiano Lora).*

2017; 2018a; 2018b; 2019; 2022). This complex yielded a significant number of prestigious goods — including many Egyptian imports such as faïence figurines of goddesses and an Udjat-Eye as well as metal objects, combs of bone and ivory, and cowry-shells (Intilia 2011; 2012; Sperveslage 2013; 2019). The abundance of these goods and the architectural design of the whole complex, coupled with the absence of domestic pottery, suggest that it served a public function. The incense burners found within the temple in Area O are small goblets made of pottery with red and dark-brown painted decorations on the exterior (Fig. 6, line 2; see Huber 2020: fig. 5). They were made using a fine, mineral tempered fabric and are characteristic of the so-called Tayma Early Iron Age Ware (Tourtet, Daszkiewicz & Hausleiter 2021).

A further temple context is building E-b1, one of the major temples of Taymāʾ, covering an area of approximately 500 m^2 (Lora 2017). It was most likely constructed during the 4th or 3rd century BCE, with substantial modifications in the Nabataean and Roman periods, and remained in use until its abandonment

A



B

Context	Period	Dating	Area, buildings	Incense burner material	Incense burner shape	No. of burners	No. of samples analysed
Public, representative and temple contexts	MBA-LBA	Mid - 2nd mill. BCE	Tower Area E-East	Pottery	Goblet Round vessel	1 1	1 1
	EIA	12th – 9th cent. BCE	Area O	Pottery	Goblets	7	7
	Nabataen	2nd cent. BCE – early 2nd cent. CE	Temple E-b1	Sandstone	Round vessel	1	1
Funerary contexts	MIA-LIA	9th – 5th cent. BCE	Necropolis of Tal'a (Area S)	Pottery	Conical cups	10	7
Domestic context	Dynasty of Lihyan, Nabataen, Roman	2nd half 1st mill. BCE – L. Antiquity	Houses and storage rooms (Areas E-South /F)	Sandstone	Cuboid burners	13	8
					Burners with 'crowns'	4	2
					Rectangular burners with inscriptions	4	4
					Triangular containers	4	2

Figure 2. *Contexts, dating, materials and shapes of incense burners at Taymāʾ with the number of analysed samples.*

in late antiquity (Lora 2017). Within the temple, one artefact — a round stone vessel with three feet — was identified as an incense burner (Fig. 6, bottom line). According to its shape and material, it has been dated to the Nabataean period. Incense burners have also been discovered in the residential quarter, which is south of temple E-b1 and was occupied from the second half of the 1st millennium BCE until the Early Byzantine period (Weigel 2019; 2020). The whole area is densely occupied with buildings of different sizes with multiple storeys and narrow streets (1,600 m^2 have been exposed by excavation). The domestic structures have several small storage compartments and larger rooms (Tourtet & Weigel 2015; Weigel 2019; 2020). Most incense burners found in the residential quarter are small, square-shaped containers with four feet — so-called cuboid incense burners — made of sandstone (Fig. 6, line 4; see Huber 2020: fig. 9), but containers triangular in shape and more elaborated forms, such as shaft-burners with 'crowns' or larger inscribed incense burners, were also discovered (Fig. 6, line 5), the latter dating to the Nabataean period (cf. Macdonald 2020: 125–127).

Incense burners have also been found outside the enclosed settlement of Taymāʾ, at the necropolis of Tal'a (Area S). This burial ground is located about 2 kilometres south-east of the oasis and south of the 'Industrial Site' (Sana'iye) where incense burners were identified for the first time at Taymāʾ (Abu Duruk 1989). There, 15 tombs of different sizes and shapes have been excavated (Beuger 2010). The most characteristic tombs, which contained multiple burials, consist of rectangular stone chambers roofed by capstones with an entrance on the

north-western side. They have been dated to the period between the 9th and 5th centuries BCE (Beuger 2010; Lora, Petiti & Hausleiter 2010; Petiti, Intilia & Hausleiter 2014). Similar to the incense burners of the Early Iron Age, these burners were pottery vessels with painted decoration. These vessels are wheel-thrown conical cups with flat, round bases (stands) and are characterised by their painted decoration on whitish clay (Fig. 6, line 3). The style of decoration has been labelled Sana'iye Painted Ware (Tourtet, Daszkiewicz & Hausleiter 2021), consisting of dark brown and red geometric motifs (see Huber 2020: fig. 8).

In order to obtain a chronological sequence for the scented substances used at Taymāʾ, and to map the contextual distribution of aromatics at the site, 33 incense burners were selected for analysis from public, funerary and domestic contexts, ranging from the Middle Bronze Age to late antiquity (see Fig. 2). To identify the aromatics that were used to create scents in the past, organic residues from these objects were collected for analysis. Additionally, eight control samples, taken either from the exterior parts of the incense burners (e.g., from feet or stands) or from soil samples, were prepared to monitor contamination.

Metabolic profiling of ancient organic residues

Since reliable identification of ancient resins is impossible at macro- and microscopic scales, biomolecular analyses were carried out to characterize the organic residues of the sampled artefacts from Taymāʾ. Resins, gums, and balsams are non-cellular natural plant exudates that are produced to protect trees or shrubs from excessive water loss and bacterial infection when they are damaged, e.g., through tapping (Langenheim 2003). From the secretory structures of the tree, such as resin ducts, an adhesive substance is released, which seals the wound of the plant and acts as a physical barrier against insects and pathogens, and can also contain bioactive compounds that help to prevent infections (Pollard & Heron 2008). These natural plant products contain numerous plant secondary (or specialized) metabolites (PSMs), which are small molecules that are in some cases taxon-specific, making them useful diagnostic biomarkers for plant identification (Singh 2016; Lukin, Merz & Schembecker 2018; Hussein & El-Anssary 2019). Among the PSMs, terpenoids are typical compounds in resins. Metabolic profiling can identify the PSMs present in biological samples, such as resins, and involves the analysis of these compounds using such techniques as gas chromatography coupled to mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) (Colombini & Modugno 2009).

The molecular composition of resins can vary widely among different plant genera and even among different congeneric species (Brettell et al. 2017). Chemical characterization of the different metabolites of certain resins can be used to identify and discern different aromatic substances (Evershed 2008; Devièse et al. 2017). For example, boswellic acids and their derivatives are highly characteristic markers for *Boswellia* plant exudates and are relatively resistant to degradation (Evershed et al. 1997; cf. van Bergen et al. 1997; Culioli et al. 2003; Mathe et al. 2004; Regert et al. 2008; Ribechini, Raffaelli & Colombini 2008; Paul 2012). They can, therefore, be considered as characteristic compounds for identifying archaeological frankincense. However, despite the source-diagnostic properties of PSMs, not all biomarkers of modern plants can withstand millennia of taphonomic alteration. Therefore, when analyzing archaeological residues, aspects such as degradation and chemical alteration over long timespans need to be considered as well (Huber et al. 2022b). Furthermore, the process of burning incense leads to oxidation reactions, thermal decomposition, and the evaporation of volatile compounds (Niebler & Buettner 2016; Niebler, Eslamieh & Buettner 2016), which can further complicate interpretation.

To screen for different incense raw materials, we created a database consisting of biomarkers that are representative of certain natural products commonly used as incense materials in the past and possessing high chemical stability. The database was established through our study of modern botanical reference samples as well as a survey of previously published studies (see Huber et al. 2023: supplementary table S3 for a list of all compounds, and table S4 for MRM parameters). Analytical standards of these characteristic compounds were obtained and used to create LC-MS/MS methods

in Multiple Reaction Monitoring (MRM) mode to screen for the presence of the compounds in archaeological samples (see below, section Materials and Methods). MRM is a targeted analytical mode of operation that is highly sensitive and specific and allows for the detection of low levels of analytes in complex samples, as is the case for most archaeological samples. Since this approach only screens for target compounds from the database, we additionally carried out LC-MS and GC-MS analyses in full scan mode (a non-selective mode), which records all compounds present in the samples, although with lower sensitivity.

Results of the metabolic profiling of incense residues

The analysis of the two oldest incense burners, dating back to the Middle Bronze Age, showed the presence of organic matter. However, only the sample from the incense burner discovered in tower W41-b1 (DA-TA-26; for a comprehensive list of all samples refer to Table 1) yielded scent compounds upon analysis. The LC-MS/MS results of sample DA-TA-26 showed a high abundance of diterpenoids, predominantly 7-oxo-dehydroabietic acid and, to a lesser extent, dehydroabietic acid and other resin acids (pimaric, isopimaric, palustric and neoabietic acids; see Fig. 3A). These resin acids possess similar structures and ionization behaviours, making separate identification difficult and we thus grouped them as 'resin acids'. All of the above-mentioned compounds are diagnostic for coniferous plant products, particularly for pine, spruce, cedar, juniper, larch, and fir resin (Sato et al. 2009; Pekgozlu et al. 2017; Salomé-Abarca et al. 2018). Apart from these terpenoids, the phytosterols β-sitosterol and campesterol were also detected in the sample. Phytosterols (or plant sterols) are naturally occurring compounds found in a wide variety of different plants, meaning that they are considered clear markers for the presence of plant material (Gylling & Simonen 2015). However, due to their widespread occurrence in the plant kingdom, phytosterols are rather generic and non-diagnostic for specific plants. Furthermore, small amounts of the aromatic compounds benzoic and vanillic acid, which also occur in many aromatics and balsams, were detected in the sample (Tchapla et al. 2004; Riesmeier et al. 2022). In this case, however, these compounds are most likely formed as by-products of combustion during the burning of incense (Tamburini et al. 2016).

The sample from the second Middle Bronze Age burner (DA-TA-03) did not show any of the characteristic compounds associated with coniferous resin, but results from the GC-MS analysis showed a large amount of saturated straight-chain fatty acids, predominantly palmitic acid (C16:0), stearic acid (C18:0), and myristic acid (C14:0), as well as the odd-carbon-numbered components pentadecanoic acid (C15:0) and heptadecanoic acid (C17:0), which are compounds found in degraded oils and fats (Fig. 3B). Additionally, the LC-MS/MS analysis also detected several phytosterols, such as campesterol, β-sitosterol, and stigmasterol, as well as the compounds cholesterol and cholestanol, confirming the presence of plant oils and mammalian fats (Evershed et al. 2002; Gylling & Simonen 2015). The absence of any aromatic markers in this sample implies that this object may have contained only oils and fats. However, it is important to consider the possibility that aromatic substances may have been added to oils in the past, but that their presence could have gone undetected due to poor preservation. Overall, the molecular composition of incense materials from the Middle Bronze Age at Taymāʾ indicates the use of coniferous resins as well as a blend of plant oil and animal fat (and possible further additives).

The results from the incense burners found within the Early Iron Age complex in Area O demonstrate the use of other scented resinous substances. The samples (n=7) taken from the small goblets inside and outside the public building O-b1 all showed a similar molecular composition. Several triterpenoids were detected in the samples through LC-MS/MS and GC-MS analysis, notably moronic, oleanonic, and oleanolic acids, as well as isomasticadienonic and masticadienolic acid and its related derivatives. Furthermore, the compounds β-amyrin, lupeol, dipterocarpol, and 28-norolean-17-en-3-one were present in the samples in small abundances (Fig. 4). These compounds are characteristic biomarkers for the resin of *Pistacia* species (Assimopoulou & Papageorgiou 2005; Sharifi & Hazell 2011; Xynos et al. 2018) and have been reported in previous studies of organic residues, for example in ancient Egyptian vessels from Amarna (Serpico & White 2000; Stern et al. 2003).

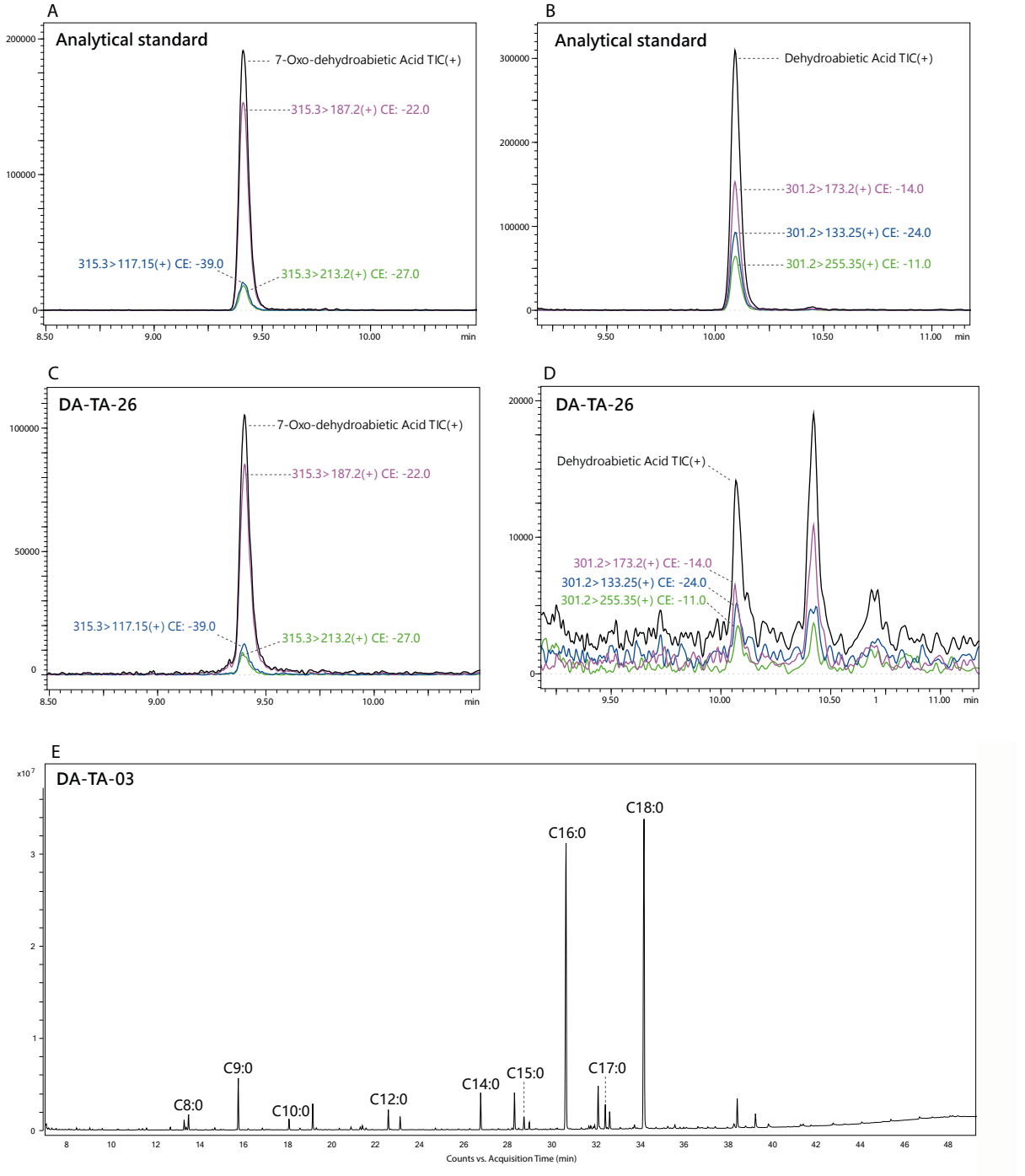


Figure 3. *Multiple reaction monitoring (MRM) HPLC chromatograms of the analytical standards 7-oxo-dehydroabietic acid (A) and dehydroabietic acid (B) compared to the presence of these compounds in the archaeological sample DA-TA-026 from the MBA incense burner (C, D). Total Ion Current (TIC) Gas Chromatogram of sample DA-TA-03 containing saturated fatty acids (E).*

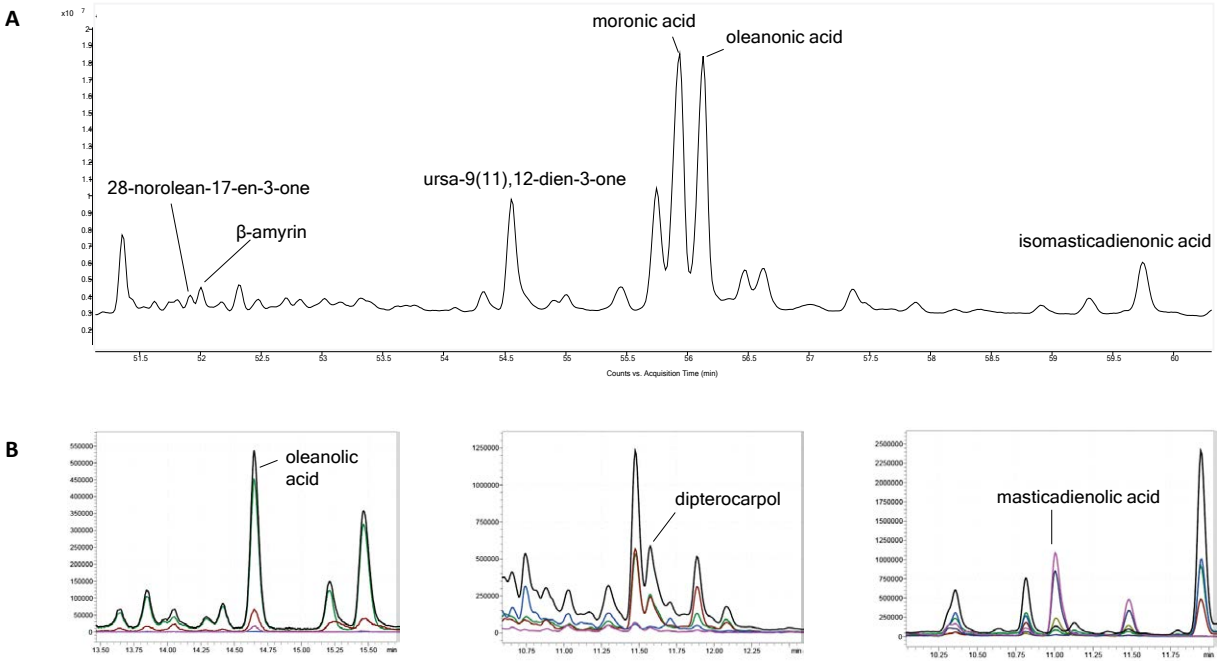


Figure 4. *(A) Partial Total Ion Gas Chromatogram of the archaeological sample DA-TA-16, showing characteristic compounds of* Pistacia *resin. (B) MRM HPLC chromatograms of compounds present in sample DA-TA-16.*

Based on this evidence, we can identify the incense material of the Early Iron Age incense burners as resin from *Pistacia* trees. Moreover, the presence of the compound 28-norolean-17-en-3-one indicates that the resin was heated (Stern et al. 2003; Tamburini et al. 2024), confirming the burning of the resin.

In contrast to Area O, samples collected from incense burners inside the tombs of the necropolis (*n*=7) exhibited a greater diversity of substances present due to the use of aromatic blends. The LC-MS/MS results revealed that certain compounds were present in all samples, originating from a main ingredient of the incense mixture, while others were only occasionally present. All samples contained high abundances of the triterpenoids α-amyrin and β-amyrin/lupeol, as well as a number of sterols and stanols. Furthermore, the GC-MS results revealed the presence of additional compounds, notably sesquiterpenes β-eudesmol, as well as epi-bicyclosesquiphellandrene. Although these individual compounds can naturally occur in a number of different plants, as a set of compounds, they have been reported in studies of *Commiphora* species (e.g. myrrh or bdellium), which could be a possible source of the main ingredient in the samples from the necropolis (Marcotullio et al. 2009; Batiha et al. 2023). To further test this hypothesis, we additionally compared the molecular profiles of the archaeological sample with different modern resin reference samples. Direct comparison with modern *Commiphora* species (*Commiphora opobalsamum* (L.) Engl. and *Commiphora myrrha* (T.Nees) Engl.) showed a high correspondence of peak distribution, retention time, and fragmentation patterns. Due to the presence of *Commiphora* markers and good matching with *Commiphora* reference profiles, the main ingredient in the incense blends is assumed to be a *Commiphora*-type resin. In some samples taken from the graveyard, additional compounds were identified. Samples DA-TA-24 and DA-TA-25 contained moronic and oleanonic acids, which are, as mentioned above, typical triterpenoids found in *Pistacia* resin. In contrast,

samples DA-TA-30, DA-TA-31 and DA-TA-04 contained dehydroabietic acid, 7-oxo-dehydroabietic acid, and resin acids, all characteristic of coniferous resin. Sample DA-TA-04 additionally contained the phytosterol brassicasterol, which occurs in oils of the Brassicaceae family, also known as cruciferous vegetables, and likely derived from seeds of Brassicaceae plants (Colombini, Modugno & Ribechini 2005; Marković et al. 2022). Based on these results, it can be concluded that the Taymā' community used either *Commiphora* resin alone or a mixture of *Commiphora* with *Pistacia* or coniferous resin for funerary purposes, and in one case with the further addition of Brassicaceae seed oil.

Finally, the results from samples collected from the residential area as well as the temple E-b1 from the 2nd half of the first millennium BCE showed clear evidence for the use of frankincense. The analyses revealed highly specific markers for *Boswellia* plant exudates, including 24-norursa-3,9(11),12-triene, 24-noroleana-3,12-diene, 24-norursa-3,12-diene and 24-norursa-3,12-dien-11-one, which were the major constituents in the profiles (Fig. 5). These compounds are thermal decomposition products (pyrolysates) of α- and β-boswellic acids and derivatives (van Bergen et al. 1997; Baeten et al. 2014; Ren et al. 2022). The boswellic acids were present in small amounts in the samples as well. Apart from boswellic acids, the compounds α-amyrenone, α-amyrin, lupeol, and incensole were also detected (the latter only in two samples). The chemical composition of these profiles shows clear evidence for the use of frankincense and the 24-nor-pyrolysates provide additional confirmation, demonstrating that the resin was burned. Frankincense was detected in cuboid containers, in incense burners with inscriptions, as well as in shaft-burners with 'crowns'.

The systematic analysis of incense burners from the residential area included the examination of samples taken from small, triangular sandstone containers with carbonized traces on the surface, designated as DA-TA-52 and DA-TA-56. The triangular shape of these sandstone

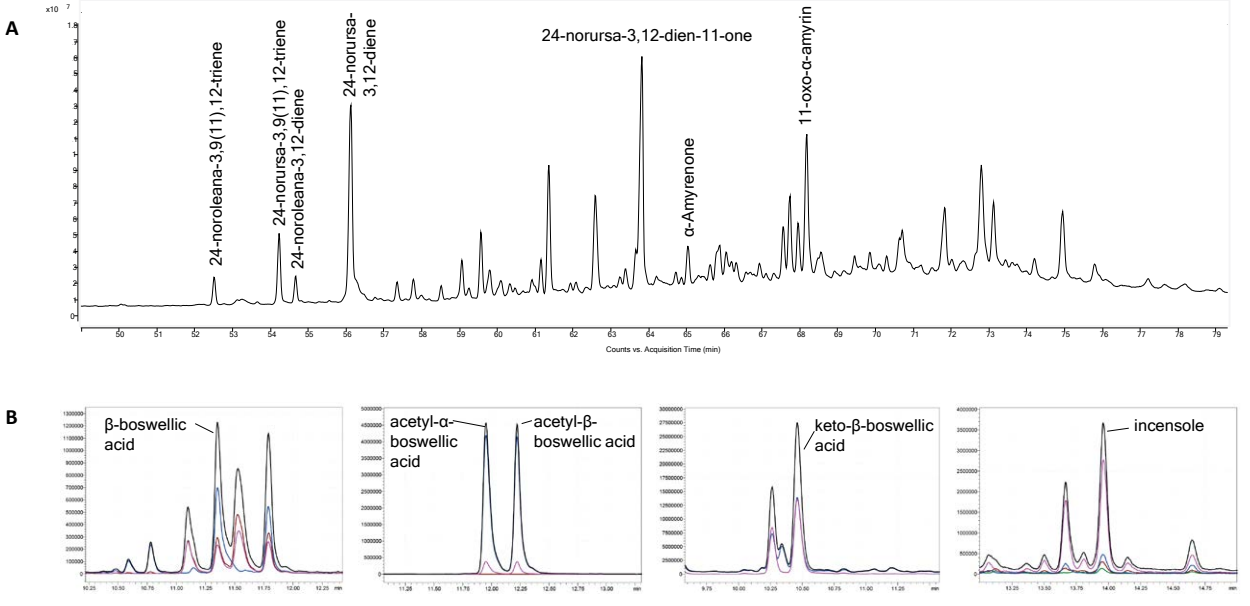


Figure 5. *(A) Partial TIC of sample DA-TA-45 with the identified pyrolysates of boswellic acids and other markers characteristic for* Boswellia *plant exudates. (B) MRM HPLC chromatograms of typical frankincense compounds present in sample DA-TA-45.*

artifacts may indicate they may have been used as lamps rather than traditional incense burners.[6] To explore this possibility, these particular artifacts also underwent testing for aromatic compounds. However, the chemical profiles revealed only significant concentrations of phytosterols, cholesterol, and cholestanol, with no evident aromatic substances. The substantial presence of these lipid compounds demonstrates that the contents of these containers were predominantly composed of plant-derived oils and mammalian fats. Consequently, the lack of aromatics, coupled with the lipid composition, strongly supports the hypothesis that these objects were more likely used as lamps rather than incense burners.

In summary, out of the 33 analyzed incense burners, 23 clearly contained incense materials, 3 exhibited only plant oils and fats, and, in the remaining 7, no aromatic substances were detected (see Table 1). None of the control samples contained traces of incense. However, some of the controls revealed the presence of plasticizers, such as phthalates, indicating plastic contamination. Importantly, these modern contaminants can be clearly differentiated from ancient organic remains.

Discussion

Our results demonstrate the use of several incense materials over time at the oasis of Taymāʾ, including coniferous resins, plant exudates of *Pistacia* trees, frankincense, and a *Commiphora*-type resin, as well as mixtures of different aromatic substances. Connecting these results with the archaeological context, a chronological and contextual pattern of aromatic use was observed (Fig. 6). Regarding the chronology of aromatic substance use at Taymāʾ, the earliest incense burned in the Middle Bronze Age was a coniferous resin, followed by *Pistacia* resin in the Early Iron Age. The Mid-to-Late Iron Age saw the first application of aromatic blends, with *Commiphora* as the main ingredient, together with the occasional addition of *Pistacia* and conifer exudates. Interestingly, frankincense was only detected in the archaeological samples from the second half of the 1st millennium BCE and, from then onwards, it seems to have been utilized exclusively. This evidence is particularly significant, as it may reflect the impact of South-Arabian trading activities during the 1st millennium BCE, specifically those of Minaean tradesmen from Yemen. These traders established a colony in Dadan and were deeply involved in the region's economic and social spheres (Macdonald 1997).

The spatial distribution of identified compounds at Taymāʾ highlights the diversity of aromatic expression at the community level, as revealed through scents whose functions varied across different contexts. For example, *Commiphora* was used specifically at the graveyard for burial practices, and was not found in other contexts at the oasis. Occasionally, other resins were mixed into blends for funerals as well. Regarding function, the scent of *Commiphora* resin is associated with funerary rituals at Taymāʾ. In this particular context, this scent could have been a part of *rites de passage* and an olfactory sign, aiding in the remembrance of the departed (Toner 2015). Olfactory stimuli have a strong impact on our memory and emotions due to the connection between the olfactory organ and the amygdala-hippocampus complex in our brain (Zald & Pardo 1997; Herz 2016; Huber et al. 2022a). As such, odors can serve as effective contextual memory cues that can help a community remember and stay emotionally connected to their ancestors (Herz & Engen 1996; Clancy 2019). Additionally, *Commiphora* resin was likely chosen for funerary purposes due to its strong antibacterial and antifungal properties, as well as its ability to cover or reduce the odor of decomposed bodies.

Another significant finding from the analyses is that the residents of Taymāʾ exclusively burned one scent in their houses, namely frankincense. Given that these buildings often had storage compartments, one possible reason for burning frankincense may have been to protect stored goods from pests and vermin (Weigel 2020). Classical authors have noted the disinfectant properties of frankincense (cf. Cato, *De Agri Cultura*; Celsus, *De Medicina*), which was not only burned to keep pests away but also used for hygienic and sanitary purposes in everyday life. The findings also suggest that the inhabitants of Taymāʾ purchased frankincense for their personal use, indicating that the settlement was not merely a transit point on the incense trade route but an active consumer. This constellation has already

[6] A lamp in the shape of a star (composed of several triangular / naviform units) has been found at the early-to-middle-Islamic site of al-Mabiyat (Al-'Umayr 2010: 469).

Table 1. *Archaeological samples of organic residues from incense burners and identified substances.*

Sample no.	Lab code	Period	Material of burner	Archaeological context	Identification
TA 18902	DA-TA 02	EIA	Pottery	Public context	*Pistacia*
TA 18903	DA-TA 03	MBA	Pottery	Unknown	Plant oils and fats
TA 18904	DA-TA 04	MIA/LIA	Pottery	Funerary context	*Commiphora* mix
TA 18905	DA-TA 05	MIA/LIA	Control	Funerary context	Control sample
TA 18908	DA-TA 08	EIA	Pottery	Public context	*Pistacia*
TA 18909	DA-TA 09	EIA	Pottery	Public context	*Pistacia*
TA 18910	DA-TA 10	EIA	Pottery	Public context	*Pistacia*
TA 18911	DA-TA 11	EIA	Control	Public context	Control sample
TA 18914	DA-TA 14	EIA	Pottery	Public context	*Pistacia*
TA 18916	DA-TA 16	EIA	Pottery	Public context	*Pistacia*
TA 18917	DA-TA 17	EIA	Control	Public context	Control sample
TA 18921	DA-TA 21	EIA	Pottery	Public context	x
TA 18924	DA-TA 24	MIA/LIA	Pottery	Funerary context	*Commiphora* mix
TA 18925	DA-TA 25	MIA/LIA	Pottery	Funerary context	*Commiphora* mix
TA 18926	DA-TA 26	MBA/LBA	Pottery	Tower	Coniferous resin
TA 18927	DA-TA 27	MBA/LBA	Control	Tower	Control sample
TA 18928	DA-TA 28	MIA/LIA	Pottery	Funerary context	*Commiphora*
TA 18929	DA-TA 29	MIA/LIA	Pottery	Funerary context	*Commiphora*
TA 18930	DA-TA 30	MIA/LIA	Pottery	Funerary context	*Commiphora* mix
TA 18931	DA-TA 31	MIA/LIA	Pottery	Funerary context	*Commiphora* mix
TA 18937	DA-TA 37	MIA/LIA	Control	Funerary context	Control sample
TA 18938	DA-TA 38	Late Roman	Sandstone	Domestic context	x
TA 18940	DA-TA 40	Late Roman	Sandstone	Domestic context	x
TA 18941	DA-TA 41	Late antiquity	Sandstone	Domestic context	*Boswellia*
TA 18942	DA-TA 42	Late antiquity	Sandstone	Domestic context	x
TA 18944	DA-TA 44	Late antiquity	Sandstone	Domestic context	x
TA 18945	DA-TA 45	Late Roman	Sandstone	Domestic context	*Boswellia*
TA 18946	DA-TA 46	Late Roman	Sandstone	Domestic context	*Boswellia*
TA 18947	DA-TA 47	Late Roman	Control	Domestic context	Control sample
TA 18948	DA-TA 48	Late Roman	Sandstone	Domestic context	*Boswellia*
TA 18949	DA-TA 49	Late Roman	Control	Domestic context	Control sample
TA 18950	DA-TA 50	Nabataean	Sandstone	Temple E-b1	*Boswellia*
TA 18952	DA-TA 52	Late antiquity	Sandstone	Domestic context	Plant oils and fats
TA 18956	DA-TA 56	Late antiquity	Sandstone	Domestic context	Plant oils and fats
TA 18960	DA-TA 60	Late Roman	Sandstone	Domestic context	x
TA 18961	DA-TA 61	Nabataean	Sandstone	Domestic context	x
TA 18962	DA-TA 62	Nabataean	Sandstone	Domestic context	*Boswellia*
TA 18963	DA-TA 63	Nabataean	Sandstone	Domestic context	*Boswellia*
TA 18964	DA-TA 64	Nabataean	Sandstone	Domestic context	*Boswellia*
TA 18965	DA-TA 65	Nabataean	Sandstone	Domestic context	*Boswellia*
TA 18968	DA-TA 68	Nabataean	Control	Domestic context	Control sample

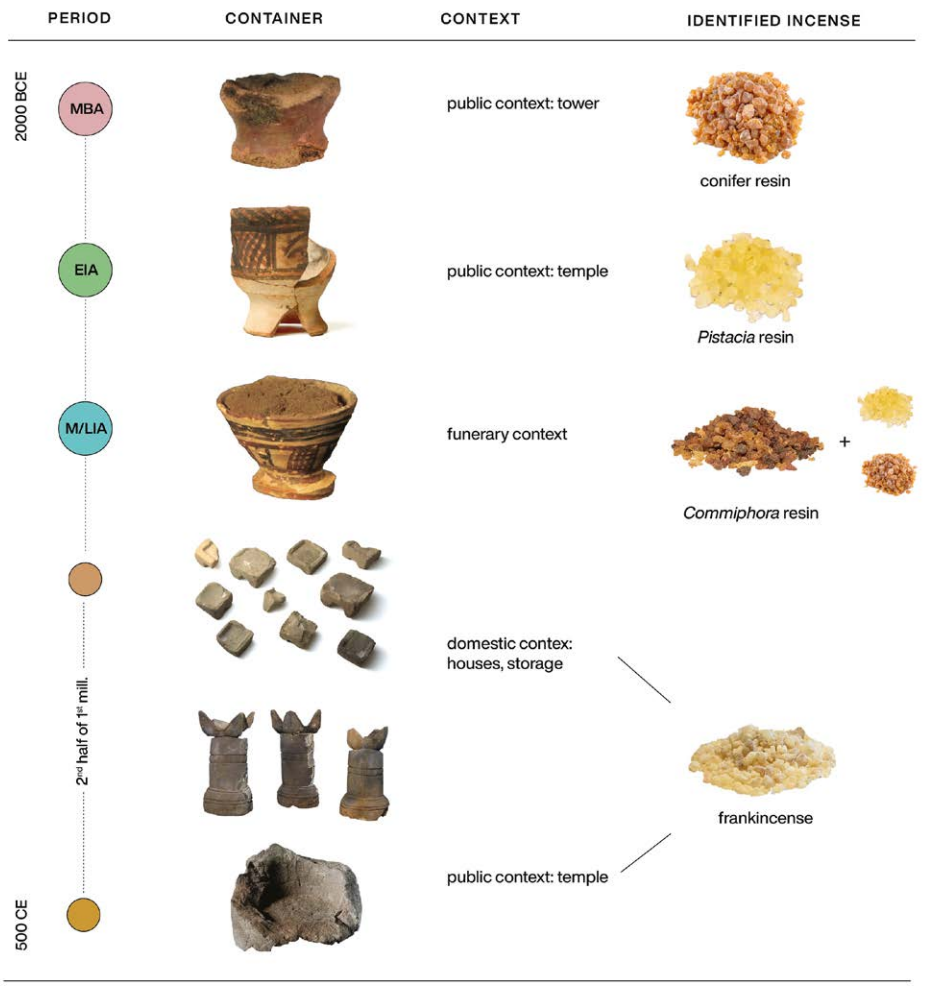


Figure 6. *Summary of aromatic substances discovered in different contexts at Taymāʾ from the Middle Bronze Age to late antiquity.*

been suggested for the site of Dadan, based on Ezekiel's prophecy against Tyre (Macdonald 1997: 343).[7]

Most of the burners found in the residential quarter date to the Nabataean and Roman periods, a time when frankincense was exceedingly expensive according to contemporary Roman writers (cf. Plinius, *Naturalis Historia* XII.30). It can be inferred that the inhabitants could afford to purchase precious goods or wanted to participate in the use of goods associated with the elite. While there is no further information on the social status of the residents based on the archaeological context, they were presumably wealthy enough to obtain what were considered luxury goods in many parts of the Mediterranean world. However, frankincense purchased in Taymāʾ was probably less expensive than in Rome, given that *Boswellia* resin was described as costly due to tolls paid along the road, both upon arrival in the Mediterranean and to a number of prior intermediaries, all expecting a profit in return (Erickson-Gini & Israel 2013; Nebes 2014). Over a shorter distance, fewer tolls

[7] An active role of the oasis of Taymāʾ in other economic contexts, i.e. in choosing copper ores has been postulated already for the Early Iron Age (Renzi et al. 2016) and may go even by far more back in time (Liu et al. 2015).

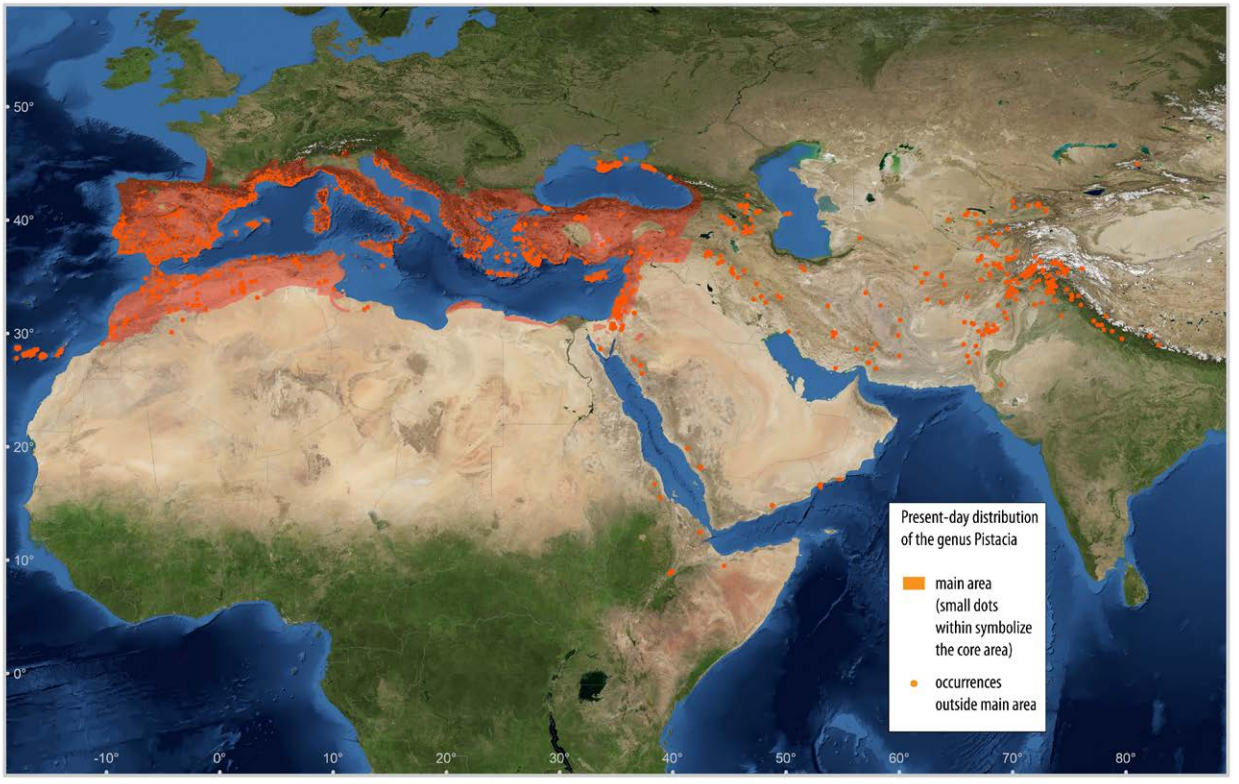


Figure 7a. *Present distribution of the genus Pistacia: The orange-shaded surface denotes the occurrences of different Pistacia species in the main area. Attestations beyond are indicated by small orange dots, following GBIF of the respective taxa.*[8] *On the Arabian Peninsula the present-day distribution of pistachio is restricted to mountainous and coastal regions (Kürschner 1998; GBIF) (© F. Darius, M. Dinies, 2024; map source: MODIS / BMNG (Stöckli et al. 2005); SRTM 2005).*

would have been paid and less intermediaries involved, potentially making the product less expensive.

The public and temple contexts at Taymāʾ displayed a more diverse use of aromatics. During the Nabataean period, frankincense was burned in the main temple, while all samples from the earlier temple context in the Early Iron Age contained *Pistacia* resin. Additionally, a coniferous substance was used in the older tower. Therefore, it seems that the choice of scents used in public contexts was influenced more by the period and the availability of incense materials at certain times than by specific contextual preferences. For instance, imports, such as frankincense may have been less common during the Bronze and Early Iron Ages, but by the first millennium BCE, when the aromatics trade had expanded significantly, were likely more accessible and perhaps more fashionable. As a result, frankincense may have become the preferred incense for temple rituals.

Other incense materials, such as *Pistacia* resin, were locally available (Dinies et al. 2015; 2016). Although modern pistachio trees are typically associated with the Mediterranean region, their natural occurrence in Arabia in the past is evidenced by Late Pleistocene and Early Holocene archaeobotanical records dating from 22,000 to 8,200 years BP (see Fig. 7a and b). Although data on the present-day distribution of *Pistacia* species in north-west Arabia are generally limited, there is evidence indicating that *Pistacia* species (*Pistacia khinjuk* Stocks, *Pistacia falcata* Becc.) are present in the Hijaz Mountains (Fig. 7a).

[8] To avoid biases due to project-based evidence, data collections associated with specific focus (e.g. DNA, agricultural) are excluded from the GBIF-dataset.

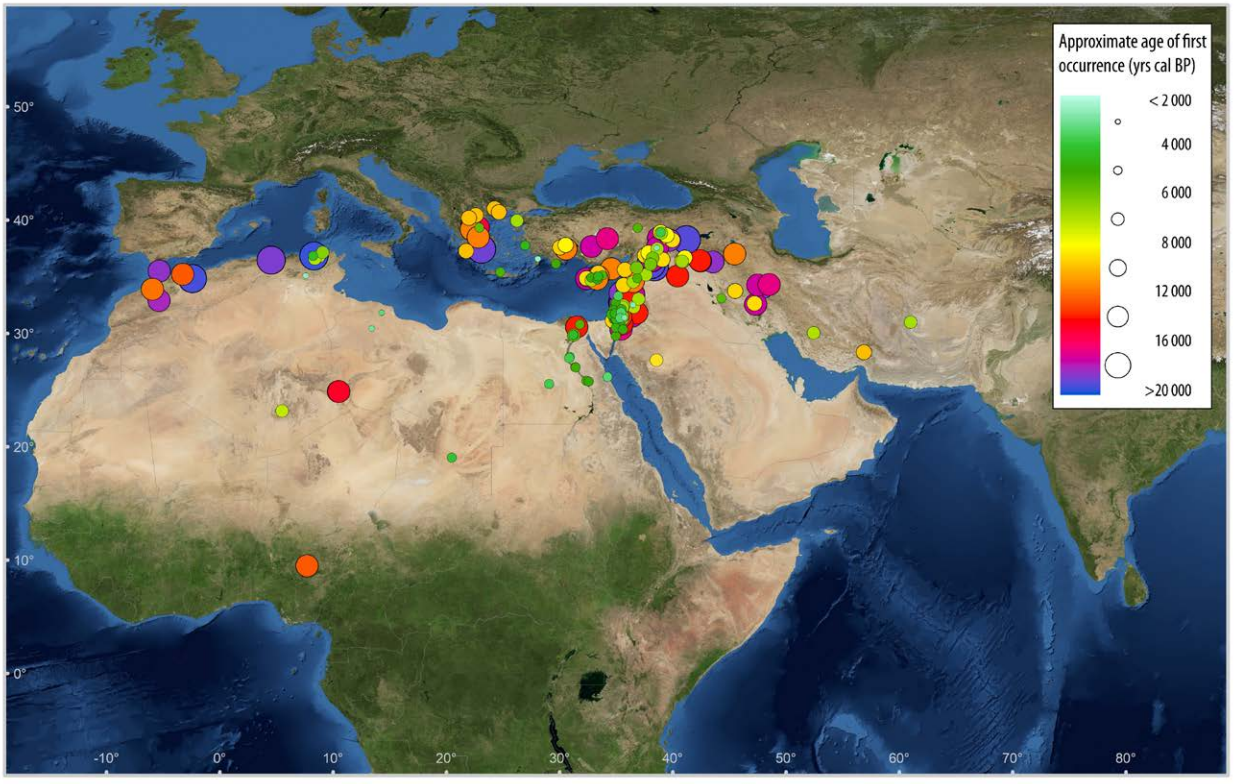


Figure 7b. *Palaeobotanical records of the genus Pistacia. For reasons of visibility, the older occurrences are marked by bigger circles, while the younger attestations by smaller ones. Palaeobotanical data includes evidence of macro-remains (seed/fruits, charcoals) as well as micro-remains (pollen)[9] (© F. Darius, M. Dinies, 2024; map source: MODIS / BMNG (Stöckli et al. 2005); SRTM 2005).*

Pistacia pollen recorded continuously during the lake-phase at Taymāʾ (ca. 9750 – 4200 years BP, see Fig. 7b) confirms the presence of pistachio trees near this natural oasis. Given Taymāʾ's proximity to the mountains, it is conceivable that the ranges of pistachio trees expanded along wadi beds, similar to the current situation of pistachio trees surviving in a wadi near the Azraq oasis in Jordan.[10] The slightly increased proportions during the short, wetter Early Holocene may even point to an expansion of such populations during more favorable conditions (Dinies 2015; 2016; Neugebauer et al. 2022). At around 4200 yrs calBP, with the sedimentary change from limnic/telmatic sediments to *sabkha* sediments linked to increased aridification, the pollen record at Taymāʾ ends, and thus the evidence of local, past pistachio populations. However, persistence of pistachio trees in favourable habitats such as wadis is probable, and today's occurrence in the Hijaz mountains about 100 km

[9] Palaeobotanical data have been retrieved from the ademnes database (https://www.ademnes.de/) for the eastern Mediterranean area, the north African evidence is based on the compilation of Amoros, Arakelyan & Vartavan (1997), data generated during long-grant research projects (BOS - SfB 109) and data retrieved from literature. The palynological data have been retrieved from the African Pollen database (https://africanpollendatabase.ipsl.fr/) and complemented by published pollen diagrams. Note that though existing, the western Mediterranean palaeobotanical records are not considered in this map.

[10] Information provided by the DAI GroundCheck project 'Climate, Deserts, and Oases: Between the Harrat and the Hejaz' of the DAI's Orient Department and the Scientific Division at the Head Office, field seasons 2021 and 2022 (directed by R. Neef & A. Hausleiter).

west of Taymāʾ, supports the continuity of pistachio populations in the region. Thus, one of the oldest identified resins at Taymāʾ could have been harvested from trees near the oasis.

The question of the origin of natural resources and their availability also links aromatics with ancient trade networks beyond the immediate local area. Cultural contacts and exchange between Taymāʾ and its neighbouring regions through time are confirmed by the presence at Taymāʾ of such archaeological finds as Chalcolithic carnelian beads (Kenoyer 2017; Haibt 2018), bronze weapons of Syro-Levantine type (al-Hajiri 2011: 112; Hausleiter & Zur 2016; Hausleiter, D'Andrea & Zur 2018), and small faïence figurines of the Egyptian goddesses Isis and Bastet/Sakhmet (cf. Sperveslage 2013; 2019 for the Egyptian connection within the materials found at Taymāʾ). The presence of incense in the oasis provides further evidence of such trading activities, involving exchanges with South Arabia or eastern Africa, the regions where *Boswellia* and *Commiphora* trees grew. *Boswellia*, a genus of the family of the Burseraceae, is not endemic to North Arabia. It is a typical Afro-Indian genus that grows in arid regions of north-eastern Africa and in mountainous regions from southern Arabia to South-East Asia (Langenheim 2003). While the species *Boswellia sacra* grows mainly in South Arabia (Yemen, Oman) and *B. serrata* in India, *B. papyrifera, B. neglecta and B. frereana* are species distributed across East Africa (Eritrea, Ethiopia, Sudan, Chad, Somalia, Kenia) (Boivin & Fuller 2009; Bongers et al. 2019). Frankincense began appearing at Taymāʾ in the Nabataean period, coinciding with the flourishing of the South Arabian incense trade (Zimmerle 2021), suggesting its source was likely Yemen or Dhofar, Oman. However, trade also linked ancient Arabia with the Horn of Africa, especially Ethiopia, during this period (Gerlach 2013; Nebes 2014). The influential Kingdom of Saba, primarily located in present-day Yemen, extended its reach to Oman and Ethiopia, with cultural exchanges evidenced by Sabaic inscriptions found in Ethiopia's Tigray region (Japp et al. 2011). This trade was facilitated by the strategic locations adjacent to the Red Sea. Consequently, African *Boswellia* species should be considered as potential sources too.

The *Commiphora*-type resin identified at Taymāʾ during the Mid-to-Late Iron Age might also originate from the south-western and southern parts of the Arabian Peninsula or the broader Horn of Africa region. There they form drought-deciduous thorn woodlands and shrublands together with acacia taxa (*Acacia-Commiphora* woodlands). In the Makkah region bordering the Red Sea at about 22° latitude, the northernmost occurrences are recorded today (Alsherif 2019; Kürschner 1998; GBIF). Considering contemporary distributions of myrrh, and assuming a similar or even slightly expanded distribution area during the Early and Middle Holocene in analogy to the pistachio findings, a regional occurrence of *Commiphora* seems probable. However, given the vast number of *Commiphora* species (over 200) and their wide distribution from Africa to the western Indian Ocean islands (Langenheim 2003), pinpointing the exact source of the resin remains challenging.

The final resin type identified at Taymāʾ originates from coniferous trees. Based on the molecular composition of the analysed residues, trees from the Pinaceae family, such as cedar, pine, fir, larch, or spruce, are the most probable sources. Although juniper trees (*Juniperus sp.*) could theoretically also be considered, this attribution is less likely due to the absence of primary juniper-specific biomarkers within the residues. These biomarkers have been detected in several other archaeological samples (Sarret et al. 2017; Fulcher et al. 2021; Rageot et al. 2023) indicating their general stability and preservation in the archaeological record. Nevertheless, caution is warranted when interpreting the absence of such markers, as the specific chemical degradation pathways in this context remain uncertain. Therefore, while the probability is low, a theoretical possibility that the resin may also derive from juniper cannot be entirely excluded.

None of the Pinaceae trees are indigenous to the Taymāʾ area (Farjon & Filer 2013). This family predominantly grows in the Mediterranean and Eurasian regions. If Pinaceae is the source of the resin, it would have been transported to Taymāʾ from the north. If verified, this discovery would constitute the first evidence for the aromatics trade as early as the 2nd millennium BCE, and would challenge the prevailing assumption that frankincense and myrrh were the main commodities traded along this route (Groom 1981). Furthermore, these results would necessitate a re-evaluation of the directionality of trade flows. Contrary to the common narrative that aromatic substances

mainly moved northwards from South Arabia, this evidence illuminates goods that may have journeyed southwards, thereby enriching our understanding of ancient trade dynamics.[11] However, in the less likely scenario that juniper is the source of the coniferous resin, local harvesting would have been possible, similar to the case of pistachio resin. In contrast to Pinaceae, juniper is the only genus of conifers native to the Arabian Peninsula, with its distribution confined to the mountainous regions. In the Afromontane evergreen woodlands of the Asir and Yemen highlands, the juniper taxon *Juniperus procera* Hochst. ex Endl. dominates the open forests, sometimes co-occurring with *Juniperus excelsa* M.-Bieb., a species with Irano-Turanian affinities, particularly in the Jebel al Akhdhar region, but primarily found in south-eastern Oman. Another species, *Juniperus phoenicea* L., primarily distributed in the Mediterranean region, has a scattered distribution in the north-west of the Arabian Peninsula, the Hijaz and northern Asir mountains, representing outposts of the Mediterranean woodland vegetation (Kürschner 1998; GBIF).

The findings of this study have revealed the significance of olfactory experiences in the ancient oasis of Taymāʾ, a site sitting at the intersection of major trade routes of the early scent trade. We have demonstrated the use of different resins in various contexts across 2000 years, offering a chronology of aromatic use from the Middle Bronze Age to the Late Roman period in Arabia at a site-specific scale. Despite the elusive nature of odours in the archaeological record (Huber et al. 2022a), aromatic substances could be identified through biomolecular study, demonstrating that the scent of individual spaces was crucial to the practices, behaviours, and perceptions of the people of Taymāʾ and that aromatics were important trade commodities for ancient economies in Arabia from an early date (Nebes 2014; Zimmerle 2021).

While the ancient Incense Road may no longer exist, its legacy and cultural heritage endure through the continued consumption of incense worldwide. This study unveils the nuanced evolution of incense use, both temporally and spatially, illuminating local practices that ancient textual sources, typically dominated by accounts of Greek and Roman trade interests, often overlook. This study has also demonstrated the prolonged practice of burning aromatics in an Arabian oasis, well before the extensive trade between South Arabia and the Mediterranean region (Macdonald 1997; Erickson-Gini & Israel 2013; Nebes 2014), highlighting the longevity and cultural embeddedness of these practices.

Material and methods

Sampling

At Taymāʾ, organic residues were found to have survived in various forms within incense burners: as fills within vessels, as visible residues on the interior surface of objects (i.e., crusts), and as materials absorbed within the porous matrix of the objects. To investigate these residues, we collected samples at the Museum of Taymāʾ's conservation laboratory using three different methods (Huber 2020). The first involved mechanical removal of visible crusts using a scalpel, yielding approximately 100–200 mg of material in each case. The second method involved drilling into the surface of the vessels to obtain approximately 2 g of powder from the absorbed residues. The third method involved direct solvent extraction of absorbed residues from the object surfaces, which was used when drilling was not feasible or permitted.

The incense burners were prepared for sample extraction by ensuring that any exogenous contamination was eliminated from their surfaces. Therefore, a thin surface layer was meticulously removed on the sampling spot of each object using a modelling drill. Subsequently, samples were taken for analysis from these cleaned sampling spots. A Dremel 200 drill, equipped with either a tungsten abrasive bit or a diamond grinding bit, was employed for the destructive sampling of the pottery or stone objects, respectively. In between sampling, methanol was used to thoroughly clean the drill bits to avoid cross contamination. In most cases, an area of approximately 1 x 2 cm was drilled into the object to a depth of 2–3 mm. The powder was deposited onto aluminum foil and subsequently transferred into solvent cleaned glass vials and further processed at the laboratories of the

[11] In this context it becomes, once again evident, that the term "Incense Road" narrows the dimension of the Arabian communication network to a limited aspect (for the reconstruction of Early Bronze Age trade routes between the Levant and its neighbours focusing on various types of precious stones, cf., e.g., Nigro et al. 2020).

Technical University Berlin (TUB) and the Max Planck Institute of Geoanthropology (MPI-GEA).

Materials

All solvents used for analysis were of analytical grade (GC- or HPLC grade). Dichloromethane (DCM) and methanol (MeOH) were purchased from Sigma-Aldrich (Munich, Germany), acetonitrile (ACN) and ultrapure water from Biosolve (Valkenswaard, Netherlands) and formic acid (FA) from VWR (Leuven, Belgium). The analytical standards isopimaric acid, α- and β-amyrin, α- and β-boswellic acids, lupeol and incensole were procured from Sigma-Aldrich (Munich, Germany), 7-oxodehydroabietic acid and α-amyrenone from Campro Scientific (Berlin, Germany), dehydroabietic acid from Carbosynth (Berkshire, UK), and pimaric acid from Abcam (Berlin, Germany). Furthermore, palustric acid was purchased from Toronto Research Chemicals (Toronto, Canada), neoabietic acid and oleanonic acid from Santa Cruz Biotechnology (Heidelberg, Germany), moronic acid from TCI chemicals (Eschborn, Germany), coumarin was obtained from LGC Standards (Wesel, Germany), and benzoic acid from Agilent Technologies (Frankfurt, Germany).

Extraction and analysis

Sample material that was not already in powder form (obtained through drilling) was homogenized into a fine powder using mortar and pestle. Solvent extraction was conducted according to established protocols (Craig et al. 2011; Huber et al. 2025) using methanol (MeOH) for LC-MS/MS analysis and a DCM:MeOH (9:1, v/v) mixture for GC-MS analysis, followed by 15 minutes of ultrasonication and centrifugation to separate the solution from the solid material. To enhance the efficiency of extraction, the extraction process was repeated three times. The extracts for GC-MS analysis were concentrated to dryness under a gentle flow of N2 gas and derivatized with 100 µL of N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA, containing 1% TMCS) for 60 minutes at 70 °C. Control samples from outside the artefact and method blanks were prepared using the same protocol.

Gas chromatography-mass spectrometry (GC-MS) analyses were conducted using an Agilent 8890 GC-System coupled to an Agilent 5977B GC-MSD at the MPI-GEA. Samples were injected onto a HP-5ms capillary column (Agilent, 60 m x 250 µm, film thickness of 0.25 µm). Helium was used as the carrier gas with a constant flow rate of 1.0 mL/min. The mass spectrometer was operated in electron impact (EI) mode at 70 eV. Initially, the GC oven temperature was set to 50°C for 2 min, then increased to 120 °C at a rate of 30°C/min and held for 2 min. It was then increased at a rate of 5 °C/min to 320 °C with a final hold time of 15 min. The transfer line and ion source temperature were set at 250 °C and 230 °C, respectively. One µL of sample was injected at a split ratio of 10:1. Data were recorded in full scan from m/z 50 to 700 after a solvent delay of 390 seconds. Injection blanks were carried out between each sample to prevent carryover.

LC-ESI-MS/MS analyses were performed on an Agilent Technologies 6460 (TUB) and on a Shimadzu LCMS-8050 triple-quadrupole system (MPI-GEA). Chromatographic separation on the Agilent system was achieved on a Kinetex C18 column (100 mm x 2,1 mm, 100A) and on the Shimadzu system on a Restek Raptor Biphenyl analytical column (100 mm x 2.1 mm, 2.7 µm particle size) and a Shimadzu Shimpack Velox SP-C18 column (100 mm x 2.1 mm, 2.7 µm particle size. Both systems utilized a mobile phase comprised of HPLC-grade water and 0.1% formic acid (mobile phase A) along with acetonitrile (mobile phase B). The column temperature was maintained at a constant 25°C, and a gradient program was applied with 0.5% B for the initial 1 min, increasing to 80% B at 10 min, 100% B at 15 min with a hold until 17.5 min, and returning to 0.5% B and holding until 20 min. Injection volumes varied between 1 and 2 µL, depending on the sample concentration. Ionization was performed with an electro spray ionization (ESI) ion source, with both positive and negative modes utilized. MeOH blanks were carried out between each sample, and all samples were analyzed in duplicate.

GC-MS data were analyzed using Agilent MassHunter Qualitative Data Analysis software 10.0 with peak identification based on reference standards, the NIST library (2.2), and with spectra reported in the literature. LC-MS/MS data were processed using MassHunter

LC-MS and Shimadzu LabSolutions software in MRM mode, with authentic analytical standards for the optimization of MRM parameters employed to screen for specific compounds in archaeological samples.

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The archaeological and ethnographic heritage of portable incense burner production in Dhofar, the southern Arabian Peninsula

William Gerard Zimmerle

Summary
This study explores the evolution and cultural significance of incense burners, particularly the cube-shaped form, in the Arabian Peninsula. Beginning with an archaeological analysis of the earliest incense burners, the study traces their development over nearly five millennia, highlighting their role in the famed Arabian frankincense trade. These cube-shaped incense burners, found in abundance across the pre-Islamic Middle East, became integral to various aspects of life, including domestic, mortuary, and personal use. The paper connects the ancient craft to contemporary practices, focusing on the continuity and adaptation of incense burner production by Dhofari potters, whose work reflects both tradition and innovation. Through an ethnoarchaeological lens, the article demonstrates how the replication and modification of these forms embody cultural memory and craftsmanship. The incense burners are presented as key symbols of historical continuity, serving both functional and symbolic roles, with their legacy enduring in the traditional practices of incense production today.

Keywords: ethnoarchaeology, frankincense, cuboid burners, craftsmanship, Arabian Peninsula

Introduction

When referring to how well building components are fitted together to form a perfect and solid unit, which is appreciated for its structure and admired for its design, architects will repeat the phrase 'the ultimate object design is form' (Alexander 1964:15). In this paper, I wish to explore the idea of small, portable, cube-shaped incense burners as architectural design models — albeit functional forms with multivariate meanings and multifaceted purposes — found throughout excavated sites in the southeastern Arabian Peninsula. In previous publications, I have detailed the extensive movement of these burners found in excavations from every quadrant of the Middle East, specifically from strata dating to the Iron Age–Achaemenid Persian periods, at the height of the Arabian trade in the Iron Age Levant and from the mid-until-late first millennium BCE southern Mesopotamia (Zimmerle 2018: 299–300). In Babylonia, for example, these forms increased in number by the 6th century BCE (Zimmerle 2020: 29–30). Similarly, in the Negev of the southern Levant, small cube-shaped incense burners increased as early as the 7th century BCE (Zimmerle 2014: 340).[1] In the southern and northern Arabian Peninsula, a shared chronological horizon for this type has begun to emerge as new forms have been excavated recently in Saudi Arabia, especially from the mid-Iron Age and later periods (Fig. 1). Overwhelmingly, the contexts from all the finds so far are mainly mortuary and domestic with some administrative-cultic findspots pointing to the portability of these artifacts across cultural domains and liminal spaces such as doorways and entry points at houses, inside tombs, and throughout caravanserai, at sites and settlements along the way on the incense roads of antiquity.

Overall, I will explore again with newly curated evidence not only the issue of what these forms were used for but also contextualize their production within the world of the miniature, architectural, model-building performances that potters and stonecutters

[1] The author recognizes that other incense burners existed earlier outside of Arabia including the famed Qustul burner from ancient Egypt (Williams 1980: 17). These are beyond the scope of this essay which centers upon the Arabian Peninsula, an area forming an 'artificial gap' in the epistemology of Near Eastern studies but is beginning to become more understood due to a significant increase in research output on Arabia in the 21st century.

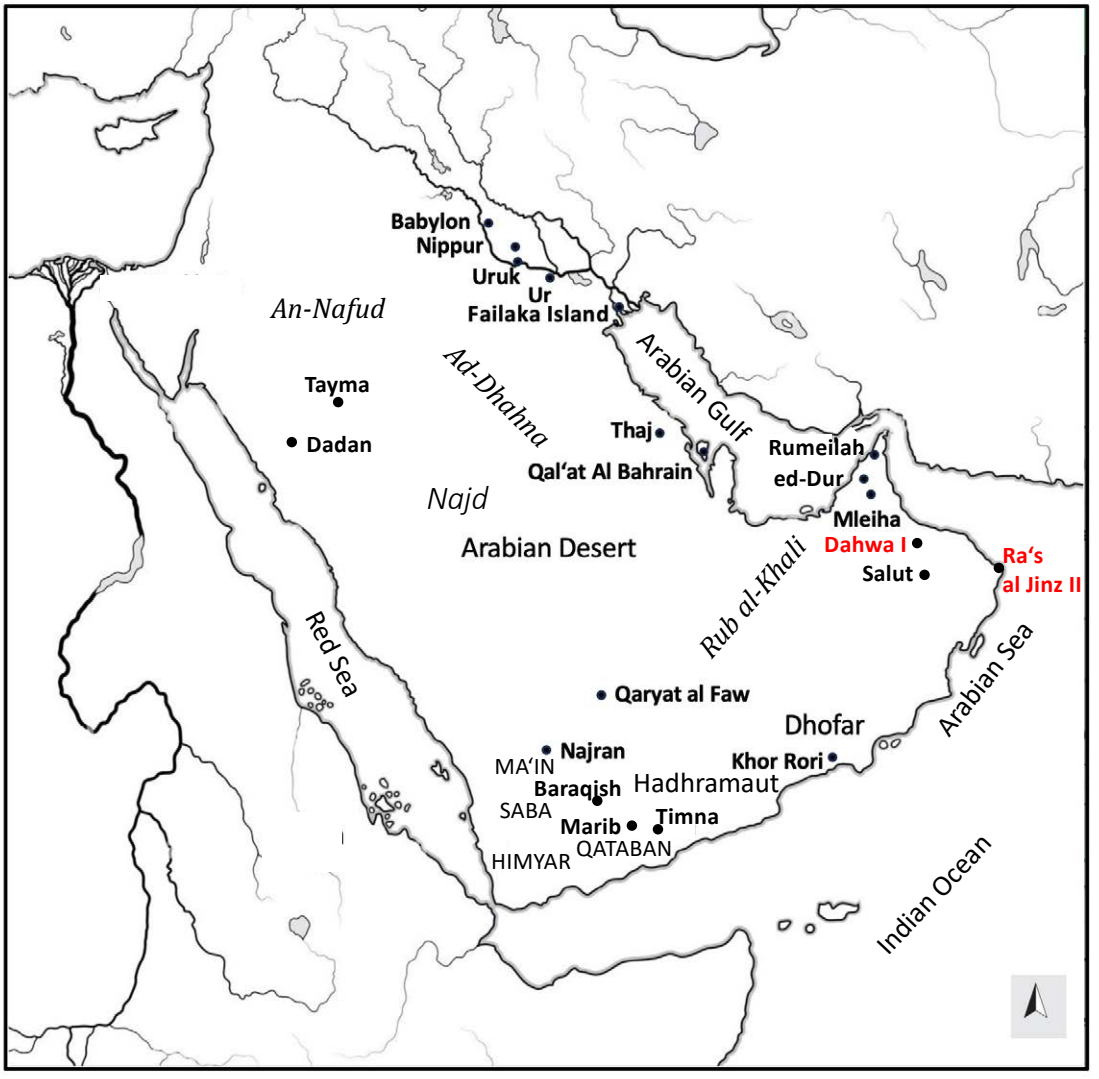

Figure 1. *Overview of archaeological sites and settlements on the Arabian Peninsula and Babylonia with cuboid incense burners in the mid-to-late first millennium BCE (Iron Age). (The Bronze Age sites Ra's al Jinz II and Dahwa I are also included as some of the incense burners excavated there are described in detail below)*

were accustomed to build as part of their repertoire of forms in pre-Islamic and the medieval Islamic ages. My analysis examines past and present assemblages of portable incense burners from Arabia, along with several early exemplars from the Bronze Age sites of Ra's al Jinz and Dahwa I in the northern Sultanate of Oman as well as highlighting late Iron Age exemplars from Khor Rori (Sumhuram) of Oman. As an overall assessment of these forms, I will emphasize that the architectural features embedded in the design function of small, portable, cube-shaped incense burners form an 'unconscious' meta-culture that was learned inside homes and within workshops as a rote set of principles that resulted in locally made forms across multiple geographic regions. Ultimately, the cube-shaped form was transmitted along the incense trade routes of antiquity leaving behind the

Figure 2. *Round horned incense burner (Photographed by Zimmerle, 2016)*

legacy of forms that remain in use within those areas that have retained handmade forms as their Arabian heritage.

The governate of Dhofar (ancient *Ẓafār*) in the south-eastern Arabian Peninsula, and the south-western region of the Sultanate of Oman, is one such place as is the neighbouring region of the Hadramawt of the Republic of Yemen today. The analysis of these forms and styles, combining both the ethnohistory of incense burners and their entangled aromatics, point to these artifacts as touchstones from the distant past. In the end, the conclusions are presented through an ethnographic and indigenous knowledge lens in which archaeological exemplars are interpreted by testing analogies from contemporary handicraft evidence collected in Dhofar between 2011 to 2021 during multiple seasons of field study.[2]

Ethnoarchaeology and a living heritage in the Wilayat of Dhofar, Sultanate of Oman

Dhofar in southern Oman, the governate often referred to as the 'land of frankincense' in heritage discourses, has served as a unique and special place to conduct ethnoarchaeological modeling because of its biodiversity and handicraft traditions that survived, yet evolved or changed, throughout the ages. As a geographical region of microclimatic diversity, it continues today as living heritage and biodiverse conservation for its inhabitants. When making a handmade, circular incense burner (a four-horned hour-glass goblet with a fitted handle, see Fig. 2), Dhofari master potter Zeina al-Noobi told me in an ethnographic interview at the Taqah Museum which I conducted alongside my local Shehri/Jibbali-language translator from the Public Authority for Craft Industry (PACI) in 2011,

> All my work is related to traditional things and heritage. I come up with new and different designs

[2] Funding for this project was granted first by the Sultan Qaboos Cultural Center, Diwan of the Royal Court, The Palace in Muscat, then by the United States Fulbright Commission in Washington, D.C., The American Institute for Yemeni Studies, Fairleigh Dickinson University, and, finally, New York University Abu Dhabi, who currently support this project now. My utmost gratitude is expressed to Barbara A. Porter for her guidance and support when first conducting research in Salalah. I am grateful for both Mohamed Al Shidhani and Iman Al Busaidi, especially because of their professional expertise and friendship to me, and whenever they provided substantial support and assistance while in the field.

> and make them, but always find myself going back to the traditional styles because I love it and it's our heritage.

This insightful statement by Zeina al-Noobi, a well-respected Dhofari potter who digs her clay from Jebel Taqah, has taught many students pottery-making throughout her years. Her key statement underscores this essay's motive to connect ancient traditions of production with modern craftsmanship as living legacies for heritage and archaeology studies.

Ghalia[3] another master potter who taught Zeina al-Noobi the craft, was also interviewed in 2011, at a Salalah handicraft center, prior to meeting Zeina. Despite the fact that she introduced newer forms into the Salalah market such as the 'high-heeled' incense burner for ladies, a burner which is procured by many local Dhofaris as well as Khaleeji tourists visiting Salalah during Khareef, she also emphasized to me the ethnohistoric value of method-making when manufacturing Dhofari handicrafts today: 'The potters of Bahla, for example, no longer use traditional paints or clays, and opt for American paints and a white 'artificial' mixer-paste added to the clay to shape and strengthen forms...in Salalah, we only manufacture the older forms.'

These two quotations emphasize the interpretative processes and craft abilities of local women in Dhofar who have become the master custodians of handicrafts. Narratives like these in the land where frankincense grows provide theoretical possibilities to be tested against the archaeological evidence to shed some light on handicraft production processes, especially for the types of incense burners found archaeologically in Dhofar, compared with the ones made today. The methodology used is almost equally the same in principle and practice as the ethnographic work conducted by the late Edward L. Ochsenschlager in Iraq as a lens for understanding Mesopotamian craft production processes. However, some differences remain taking into consideration the role of modern practices and cultural changes in the southern Arabian Peninsula, which has developed rapidly since the late Sultan Qaboos bin Said Al Said ascended the throne in 1970. I hope this ethnographic work assists in understanding how incense burners were made in the Arabian Peninsula, and as an ethnoarchaeological experiment within the heartland of Arabian aromatics, factors development and change into the study since I began the project in 2011. Periodical reviews of the craft industry are ongoing so that change is documented yearly. But on the role of ethnography for the sake of archaeology, Ochsenschlager wrote:

> We can understand and better appreciate, for instance, the degree of coordination and skill required for everyday activities in ancient times because both modern and ancient peoples used similar artifacts for similar purposes (Ochsenschlager 2004: 6).

While there are inherent problems with such a statement that seems to deny cultural change over the *longue durée*, as it may dismiss completely how development alters societies overtime, the overall principle is valid to a degree especially in the southern Arabian Peninsula: that craftspeople today in traditional societies remain 'keepers of the past' who preserve indigenous and traditional knowledge as living memories and for the pride of place. The collected evidence which is presented below as interview statements and photographs indeed elevates the Sultanate's heritage of terracotta incense burners as a reference for future work when archaeologists and anthropologists learn and apply ethnoarchaeological analogies from the field. Therefore, the starting point of this study is indeed archaeological as two settlements serve in the background: Ra's al Jinz and Dahwa I. Both places are where the first incense burners of the Arabian Peninsula have been found. Dhofar, on the other hand, and its contemporary handicraft tradition of incense burners, along with its assemblage of incense burners excavated from Khor Rori (Sumhuram), will remain in the foreground to be analyzed as archaeological and living heritage below.

Dahwa I and Ra's Al Jinz, Sultanate of Oman

Beginning in the Bronze Age northern al-Batinah of the Sultanate of Oman, the Umm an Nar settlement site of Dahwa I yielded a rounded terracotta vessel, identified as DH1.016-S10:R8:9 which was interpreted by the excavators as an incense burner (Al-Jahwari & Douglas 2021: 176). The context for DH1.016-S10:R8:9 was domestic, and it was found in building S.10 in DH1. A.

[3] Ghalia wished to be identified by her first name only. According to Zeina al-Noobi, "Ghalia perfects traditional styles and understands our heritage because she loves it" (Zimmerle, Interview in Arabic-Jibbali, 2011, transcribed by Susan Al Shahri).

Excavated recently by both Nasser S. Al-Jahwari and K. A. Douglas at the Sultan Qaboos University in Muscat, they refer to it as an hourglass goblet by its form and dimensions (Al-Jahwari & Douglas 2021: 173). While the form is not characteristic of a cube-shaped incense burner, its shallow basin seems to indicate to the excavators that it might have been once used as a vessel for burning incense or resins. Furthermore, as evidence, Al-Jahwari and Douglas refer to another possible incense burner from the third millennium Tall Abraq as an outlier but hybrid form that combines the round and cube shapes in one (Potts 2000: 125).

While Dahwa I may serve as the starting point for understanding the tradition of rounded, goblet-like incense burners in Arabia, specifically in the Sultanate of Oman, the site of Ra's al-Jinz (RJ-2) is strategically key for understanding the characteristic cube-shaped or rectangular-shaped incense burner tradition of the Sultanate (Zimmerle 2018: 298–299).

RJ-2 occupies a strategic coastal position along the south-eastern Arabian Peninsula in the Sultanate of Oman lying between eastern Asia on the one hand, and the Arabian Peninsula landmass on the other. Its location in the Ja'alan Wilayat in Oman can be physically characterized as a low headland that juts into the Indian Ocean. The site is rich in archaeological remains due to the marine biomass in the ocean waters, preserving significant biodiversity and, more importantly for our purposes here, preserves archaeological material culture, such as three (two fragments and one intact whole vessel) of the earliest incense burners found thus far in the Arabian Peninsula (Cleuziou & Tosi 2000: 23–24).

Ra's Al Jinz (RJ-2): stratigraphy of the site

By the end of the fourth millennium BCE, complex social organizations emerged around RJ-2 because of economic trade with southern Mesopotamia. Between the end of the fourth millennium and the middle of the third millennium, a complex culture emerged at RJ-2 because of early seafaring that included simple material culture and luxury imports from India. The imports included a carved ivory comb with a row of dot-and-double circles (DA 8387) and a cast of a copper seal with Harappan writing on it. In the third millennium BCE specifically, this trade with Mesopotamia and India intensified as Ra's al-Jinz II ultimately stood at the crossroads of an international system of complex exchanges.

Excavated both by the late archaeologists Serge Cleuziou and Maurizio Tosi, the site of RJ-2 was first explored and surveyed in 1981 by Tosi after he found Harappan pottery sherds on the site's surface. From their initial studies of the place, Cleuziou and Tosi described the area as a 'single continuous archeological compound', with continuous occupation since the sixth millennium BCE (Cleuziou & Tosi 2000: 23–24).

By 2500 BCE, major urban developments in the southern Arabian Peninsula were tied to economic relations with the industrial centres of the Indus Valley. Both Ra's al-Jinz II and III (RJ-2 and RJ-3) were settlement examples of these developments. Ra's al-Jinz began to reap the benefits of urban qualifications as the most important gateway as a centre coastal town between the Arabian Sea and the Indian Ocean. The processing and shipping of fish became the driving force of the economy. Such maritime exchange would have impacted southern Mesopotamia early on and continued to affect its development throughout the second and first millennia as one of several seasonal fishing posts along the Indian Ocean (Cleuziou & Tosi 2000: 68). Most of the economy of the area was subsistence and dependent upon this fishing industry. Fishing is documented at the site by evidence of metal hooks and net sinkers of the Early Bronze Age, as well as the skeletal remains of fish. Monsoon winds in the summer would have made fishing impossible; therefore, the fishing season lasted from October to March, the same as it is today. Besides its position along the maritime trade circuit, the climate alone would account for seasonality and mobility at the site which obviously impacted settlement patterns and provide adequate reasons for why the material remains analyzed below were indeed left behind seasonally (Cleuziou & Tosi 2000: 42–43).

Against the backdrop of this environmental landscape, the third millennium BCE historically was a cultural period of complicated political transactions and cross-cultural engagements. Luxury goods brought to port were traded between the Gulf and India, on the one hand, and Oman and Mesopotamia, on the other. Chronologically, two major sequences can be discerned from the excavations of the mud-brick Buildings I and II at RJ-2, although these phases cannot be applied to the site uniformly. One sequential phase was dated to

the fourth millennium, originally called Period I. It consisted of stratigraphic layers beneath the Early Bronze Age cutting into bedrock. A brief chronological gap was found to exist between this layer and the Early Bronze Age, or what was identified as Period II. There was a period of widespread site abandonment at this time, although the entire site was not abandoned, as attested by the tombs found at RJ-6 between 3200 and 2600 BCE.

The mud-brick houses of Period II, the Early Bronze Age, date to the third quarter of the third millennium. This phase signified a new occupational phase in the history of RJ-2. The pottery of this phase, as noted above, included many Indus Valley imports. This period was also assigned to the late third millennium, according to the associated radio-carbon dates (Cleuziou & Tosi 2000: 69). In this area, the site was abandoned in ca. 2000 BCE. For the rest of the site, it is difficult to follow where and when the site was occupied in the Early Bronze Age. Period II corresponds to the first phase of occupation of the southern conglomerate of buildings. Period III begins with the first construction of the northern compound of buildings at the site. This phase included the abandonment of the Southern Compound and the later occupation of the Northern Compound. Period IV corresponds to a set of buildings built over the Northern Compound area. In the Northern Compound were the loci where the incense burners were found.

The provenience of the sandstone incense burners

The Northern Compound, where the fully intact incense burner (DA12728, Fig. 3) was excavated, consisted initially of seven buildings constructed in the following order: VII, VIII, VI, IX, X, L, XI, and XII. The earliest rooms were built when the Southern Compound was still under occupational use in Period III. After the Southern Compound was abandoned, the rooms in the Northern Compound remained occupied. After they were abandoned, however, Building IV was built to the west using Western Wall VII as a retaining wall. This building, if it can be securely dated to Period IV, was the final building to have been constructed in the Early Bronze Age occupational sequence at RJ-2.

Figure 3. *RJ-2, incense burner, DA 12728, from the Northern Compound, National Museum of the Sultanate of Oman (Photographed by Zimmerle, 2012)*

Building VII, on the other hand, was the earliest unit of this compound. This installation had a rectangular plan (Cleuziou & Tosi 2000: 34). The artifacts recovered from this building were like the ones found in the Southern Compound. Likewise, the finds included net sinkers and shells evident of maritime culture. A courtyard was formed from the extension of Buildings VIII and IX. Cleuziou summarized this compound in his analysis of the plans emphasizing the single, autonomous unit layout surrounding the courtyard for the Northern Compound: (1) The Northern Compound had a different organization centred around an eight-room unit, Building VII, by far the largest on the site with a surface area of about 100 m² and a courtyard used for domestic purposes; (2) Clusters of two rooms in Building VII, IX, VI, and possibly VIII, were used as storerooms; (3) Clusters of Buildings VI, VII, VIII, IX, and X together formed a single living unit (Cleuziou 1995: 143).

Most importantly, the overall design of this layout was interpreted as a matrix of family units. The families living inside there must have operated cooperatively both economically and domestically. Cleuziou read the architectural pattern of the compound as a reflection of how nuclear families were grouped into larger

residential compounds with extended family members occupying smaller rooms as part of a kinship ideology of the Early Bronze Age Arabian society (Cleuziou 1995: 143). He highlighted three of the buildings, numbered IV, VII, and IX, which shared two small storerooms.

Room IX, a trapezoidal building formed by two rooms, contained evidence of craft-related activities, including flint tools, fragments of copper debris found as raw material such as fragments of crucibles with metal deposits, three flat tools usually described as 'razors' (DA 12732, 12733, and 12736), carnelian beads (DA 12772), and the incense burner, DA 12728. This intact incense burner was discovered in the north-eastern corner of the room, together with various stone objects including a net sinker and an hammer-stone.

The incense burner DA 12728 is the first rectangular form with four legs in existence, a finely crafted, square-rectangular (proto)-type of the cuboid four-legged burner in the history of the Arabian Peninsula. It is not only the oldest excavated cube-shaped incense burner from Arabia, but it is also a solid and heavy form (1.077 kg) serving as an example from a defined context. The incense burner was excavated from a deposit beneath and sealed by a layer of bricks and clay from the walls surrounding it. Given its durability as made from sandstone, the position suggests that this incense burner was left behind in a corner of the room with associated tools for the next season.

Two fragments of identical four-legged containers or incense burner vessels were also found at Ra's al-Jinz in previous seasons, the first one (DA 10850, Fig. 4) in the fill of a pit (su 2500), and the second, the side leg of the incense burner (DA 11971) from Room IV (su 3154). All in all, those incense burners were plain and displayed no signs of decorative incisions or carvings that were fading from time. This ultimately contradicts the rich intercultural style of the third millennium that is attested on soft-stone artifacts of the period whose origins were often from elsewhere such as Iran or the Indus Valley.

As for its archaeological find-spot, when the intact incense burner, DA12728, was recovered from the northern domestic compound at RJ-2, it was dug out of the ground upside down and when excavators rotated the container (Zimmerle 2021: 27). There, they found the deposit of a black greasy residue in its 1.5 cm depressed

Figure 4. *RJ-2, incense burner fragment, DA 10850, from the fill of a pit (su 2500), National Museum of the Sultanate of Oman (Photographed by Zimmerle, 2012)*

center (Cleuziou & Tosi 2000: 53, 60). Additionally, Cleuziou and Tosi referenced the function of the form in their report stating that the sandstone burner was by no means a precious or exceptional object, but an item of standard household equipment (Cleuziou & Tosi 2000: 54, 61; Zimmerle 2018: 298). They wrote: 'The close similarity in size and shape of these Bronze Age burners with those traditionally used for aromatics throughout Arabia until today strongly suggests that they too were in similar widespread use for daily household and ritual activities' (Cleuziou & Tosi 2000: 54).

When retelling the story in the aftermath of discovering the incense burner, Cleuziou and Tosi were unclear of its purpose or function when they found it. They simply stated, they were unable to determine its form, but they became aware of it by their Omani workman who referred to the artifact excitedly as an incense burner, something they likely recognized cognitively and immediately as a shape that 'had endured till the present day' (Cleuziou & Tosi 2000: 54). Cleuziou and Tosi wrote further on this point making the following statement, 'the local Omani workers of

Ra's al-Jinz did not hesitate to call it a mabkhara and passed it to one another with the traditional formal gestures' (Cleuziou & Tosi 2000: 54).

The attribution of forms: Aristotle's views on the senses

The Omani workmen's astute perceptibility of DA12728 recalls fundamental philosophical points written by the classical thinker Aristotle in his mature but brief treatise on the 'five senses'. In this treatise, entitled *De Sensu*, which was part of his broader *Parva Naturalia*, the famed philosopher explains how human senses working together within the 'soul', or what we would today identify as the mind, are enabled physiologically to scale the rightness of a form cognitively. He wrote, 'In perceiving the object which first set up the motion (e.g. a bell, or frankincense, or fire) all perceive an object numerically the same; while, of course, in the special object perceived they perceive an object numerically different for each, though specifically the same for all' (*De Sensu* 6 446b21–25; Marmadoro 2014: 138).

Accounting for the ability to recognize something as both similar and yet different along single or multiple dimensions as special characteristics of attributing the correctness of form, Aristotle was adept in his study to set the standards for the recognizing the extremes between the vices and virtues of sensing the contrariety of smells (*De Sensu* 4, 442b18–19; Baltussen 2015: 31). Within the Aristotelian system for understanding the perceptible qualities of sense objects, the senses are always applied but the scale in which the form of an odor or a size of an image-form could be described was often indiscriminate on the person (Baltussen 2015: 31). Nevertheless, the Aristotelian mode of thinking emphasized clarity and description by perception which meant that human beings had the ability collectively to recognize the rightness of a form based upon its attributions (Baltussen 2015: 31). In short, if it felt, smelt, and looked like an incense burner upon examination, it was indeed an incense burner.

One can ascertain that the most remarkable aspect of incense (gum-resin) burning and using an object such as a portable burning cube or rectangular-shaped device in its cultural environment is the entire systematic process of human beings' sense organs sensing artifacts. In the case of an incense burner, the senses rely on the kinetic potentiality of an object to be released into a medium such as the wafting of smoking fumes that are smelt, felt, and visualized in the space between the two existing forms, the sense-object, and the sense-organ. In the case of incense burning being generated from a cube-shaped container specifically, the kinetic energy released in the open oxidizing air is ultimately the result of fire conduction, and upon visual recollection, the sounds and smells of burning resins, that are stored inside the faculties of memory due to how olfactory bulbs function. The neuro-power of 'fire-branding' creates enough combustion to display multiple meanings and messages that are sensorily experienced instantaneously when the potentiality of the human senses is activated. Once the sense organ such as the olfactory bulb is within smelling distance to the sense object, as smoking resins permeating into the medium of air from a four-legged 'table' incense burner, which was generated by the intense heat of combustible flames, it triggers neurons within one's mind to recognize and name the attributions of the principal parts of its form based upon smell (Fig. 5).

In summary, applying Aristotle's theory rudimentarily to the form of the incense burner helps us attempt to reconstruct how the Omani workmen recognized the right attributes of DA12728 because of the many multifaceted meanings associated with the artifact-form based in part upon their senses, and most of all, predicated upon their living memories of having used similarly shaped artifacts from as early as adolescence. These sensory aspects cemented the form in their collective memories as heritage touchstone for Omanis, giving significant cultural meanings to these portable devices. In this next section, these meanings shall be further unpacked stressing the relationship between making things and creating collective memories surrounding natural resources such as frankincense and defining the language of heritage for traditional communities as related to archaeological evidence.

Dhofar: the legacy of frankincense heritage

The Dhofar Governate of the south-western region of the Sultanate of Oman today forms a part of the larger Indian Ocean subtropical zone, a biodiverse

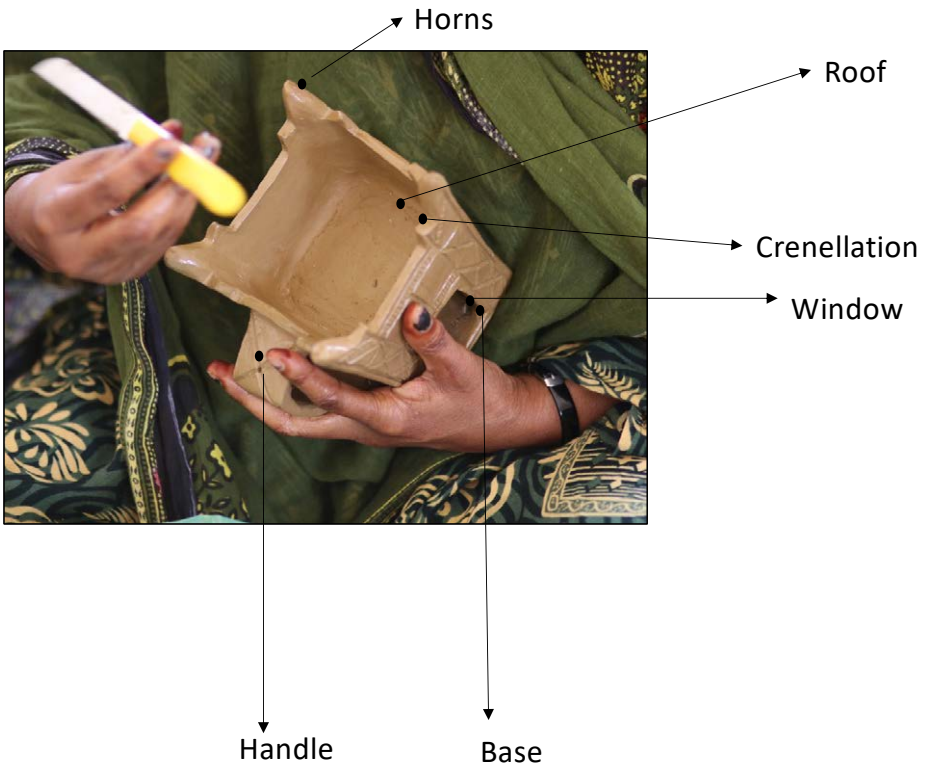

Figure 5. *The principal component parts of a contemporary incense burner from Dhofar (Photographed in Mirbat by Zimmerle)*

microclimate, that includes the horn of east Africa, the southern Arabian Peninsula, and western India. Due to a unique climatological landform mass, an interesting and unique biodiversity of flora has formed in this region. As a result, Dhofar is separated into four ecological zones with the highest concentration of some Arabian flora, or *Boswellia sacra* trees to be found in the mountains ranging from Hasik in the west to the Habban in the east, especially in the more arid areas (Morris & Miller 1988). On the northern slopes, the lack of moisture and free of clouds from the south-west monsoon winds and rain offered enough aridity for the best resins to have been cultivated in the past, according to the Englishman G.N. Jackson who was stationed in Dhofar in 1943 (Owtram 2014).

In the monumental ethnobotanical study, *Plants of Dhofar*, Miranda Morris and Anthony Miller presented a sweeping overview of the history of the origins and geography of *Boswellia sacra* in modern times, confirming that *Boswellia sacra* is 'without a doubt the most famous plant of Dhofar, and indeed was of vital economic importance in Dhofar within living memory' (Morris & Miller 1988: 78).

Additionally, the native languages spoken in Dhofar are modern South Arabian (MSA) which have had a pivotal impact on the terminology in the region for flora and fauna lexicographically. A primary example is the nomenclature for the frankincense tree known today as *shajarat al-lubān* in Dhofari Arabic and as *megerot* in the Modern South Arabian Shehri/Jibbali language of Dhofar (Morris 2012: 104). Specifically, the oleo gum resin extracted from the *Boswellia* is identified as *lubān* (*lbn*) in Dhofari Arabic and *saḥaz*/*sēḥez* in the Jibbali and Mehri languages, respectively (Morris 2012: 104; Morris 1997: 233; Müller 1976: 127).[4]

The latter term seems not to have been restricted to the oleo-gums of the frankincense trees but referred to the resins of the entire *Commiphora* species of the *Burseracaea* family by native-speaking Dhofaris of the Jibbali language. Michael Macdonald has suggested

[4] See also Zimmerle 2020: 40 where the Dhofari prayer in Jibbali begins with Dhofari Arabic (*lubān*!).

Figure 6. *Boswellia sacra tree globular gum-resins of the first cut in Dhofar (Photographed by Zimmerle, 2021)*

that *lbn* is a Semitic root from the language of northern Arab traders, 'the language of merchants', as the word is not used for frankincense in the language of South Arabia, 'the language of the producers', or the tongue of the 'cutters' (Macdonald 2020: 00:7:47–00:8:05; Sima 2000: 265). This point is likely very important as it demonstrates how frankincense has been preserved so well linguistically in the history of the Arab language by outside merchants or traders who usually named the resin and its grades on the basis of its colour.

Unlike other types of trees, *Boswellia* (frankincense) species require specific climactic conditions to cross-pollinate and grow productively (Fig. 6). Addressing these restricted climactic requirements in Dhofar, Morris and Miller, who limited the spread of *Boswellia* in antiquity from Hasik in Oman to Habban in central Yemen, unlike today where it grows further afield, specified that 'the erroneous understanding that frankincense trees "only grew in areas of good rain" has persisted even among some modern authorities... the Bents, travelling in the 1890s, only saw the (inferior, rather stunted) frankincense trees that grew (or had been planted according to Wendell Phillips) on the seaward-facing slopes of the monsoon mountains, and consequently also inferred that such trees grew in the monsoon-affected areas' (Miller and Morris 1988: 78).

Geographically, the main harvest of the Dhofar, or its best quality of frankincense (*saḥaz negdi*), was collected from the groves in the western-eastern highlands, the Negd, and desert regions beyond where the monsoon rains stretch across the region during the Kharif (mid-June to mid-September) (Morris 1997: 246). Morris also noted in her study that the superior trees were found along the sides of the wadi beds, while the inferior trees grew on flat, stony plateaus (Morris 1997: 239–240).

Using their traditional indigenous knowledge from working in these areas, local Dhofari people also distinguished between different types of gum resins based on their cartographic location, or by the seasons (ie. summer versus winter gum) (Morris 1997: 246). Furthermore, according to Morris, when the demand for frankincense increased, 'a second harvest was introduced', as also described in some early Classical sources (Morris 1997: 239).

Morris' work has documented the harvest production where daily laborers were involved and brought their supplies including water skins, baskets, and blades for cutting *Boswellia* bark (Morris 1997: 236–237). She stressed that the workers progressed from tree to tree in open groves, cutting surface triangulate wounds into the barks at spots where 'veins' would be pierced to flow into a main 'artery', then dropping the sticky gum resins that were cut from the trees into various-sized baskets called *zembīl* and *maḥer* (Morris 1997: 240). Unlike today, where overcutting often abounds, the first incision was performed gingerly to sustain the longevity of the tree and prevent long-term damage to its wood. For the second incision, returning after about twenty days, the cutter peeled off the scab that had formed from the cut with his chisel, the blade known as *munṣif* in Jibbali and *al-munḳif* in Dhofari Arabic (Fig. 7), while depositing the milk-like liquid gum resin into a four-handled basket called a *məkelil* in Jibbali (Morris 1997: 237–238). The gum was then dried and stored in caves and cave shelters along the sea, especially near Hasik. The cutters

Figure 7. *Collecting frankincense resin from the Boswellia sacra tree, Wadi Dawkah (Photographed by Zimmerle, 2023)*

soon after returned to their caves and cave shelters to transfer the day's collection to their storage (Avanzini & Pavan 2011: 31, fig. 11b). In pre-Islamic and early Islamic times, it is likely here that Dhofaris or their families once created rock art images on the walls and ceilings of the cave shelters where they dwelt pastorally and stored their resin collections (Zimmerle 2017b: 2–3).

The gums left in the storage pits were eventually packed into palm-made buckets, the cutters on camels meandered down the coast to boats where the resins were loaded and transported via maritime trade. Morris relays that the cameleer traditionally asked the cutter for a 'double handful of gum resins in addition to his share of the gum his camel carried' (Morris 1997: 240, 245). There the gum resins *fuṣūṣ* were broken up into smaller, crystallized granules, like gemstones, winnowed, packed again, and loaded onto boats with a ten percent tax added onto each sack (Morris 1997: 240).

This trade has decreased over time especially in the 20th century. In the 1907 diaries of W.G. Grey, a British Major, he recorded that the trade of frankincense had dissipated, 'Fishing is carried on by the poorer classes and the little export trade there is, is in frankincense which is brought down from the Samhan range and exported chiefly to Bombay in dhows which come from thence with rice, cloth, etc. for sale of exchange' (Owtram 2014).

The prized exemplars of frankincense gum resins were usually white to translucent, shaped like bulbous, tear-droppings and not as 'the long, thin, icicles' and referred to as *luḳeṭ* from 'the verb to pick up, or gather small objects, as grains', as *ləblel* 'pearls', or as *ḥanzob* 'beads' and 'likened to *fizzet*', 'silver', (Morris 1997: 240). This grade was the frankincense type reserved for rituals, witchcraft exorcisms, and the treatment of the sick (Morris 1997: 240), and today most of this type is reserved for the Royal Court, according also to the ethnographic interviews that I conducted with shopkeepers in Haffah Souq in 2019 and 2020. On the quality of the resins, Morris wrote that the highly prized

Figure 8. *Sorting Boswellia sacra gum-resins in Dhofar, Haffah Souq, Salalah (Photographed by Zimmerle, 2011)*

Figure 9. *Incense burners and related crafts from Mirbat, Dhofar (Photographed by Zimmerle, 2016)*

specimens '*luḳeṭ* were separated from lesser quality ones, and the *luḳeṭ* were worth double other gum' (Morris 1997: 240). Such pieces of special crystallized gum resin were rare discoveries during the harvest period and therefore prized for their special applications (Fig. 8).

Dhofar is where a bio-diverse sphere cultivated *Boswellia*, which in turn, drove the long-term development of a domestic ceramic specialization in which the dried resins could be burned effectively, and their scents applied inside the home. The British explorer Bertram Thomas first observed pottery-making as a domestic craft in Dhofar when he travelled through the Empty Quarter. He wrote that the women's job was restricted to grazing and tending cattle, collecting firewood and water, making pottery, and mainly bearing children (Thomas 1932a: 98). Almost one hundred years later since Thomas' account, the production of clay cuboid incense burners today is made by women in the home with at least seven different types and shapes of incense burners manufactured including forms that take the shape of boats including dhows (Fig. 9).

Dhofar: forming and designing cuboid incense burners as handicrafts

In 2011, an ethnoarchaeology project on handicraft production in Dhofar was invited and sponsored by the Sultan Qaboos Cultural Center, Diwan of the Royal Court, The Palace, in Muscat, was initiated in the land where frankincense (*Boswellia*) has been cultivated. Incense burners of many forms are made there today (circular, cube-shaped, ships, high-heels) and all of them, regardless of their shapes, are referred to as either a *mibkhara* (pl. *mibākhīrah*) from the Arabic root 'to burn', or as a *majmar* (pl. *majāmirah*) from the Arabic root *gmr* or 'fire-coal', a noun which appears in both Shehri/Jibbali and in modern standard Arabic (Lipiński 2001: 147). The interviews with craftswomen about incense burner making and using for this study were conducted in both Arabic, Jibbali, and English, and aided by a tri-lingual translator supplied by the Ministry of Handicrafts, Sultanate of Oman. To understand how incense burners were manufactured, a lexicographic database on incense burners and incense burning terminologies from the modern South Arabian languages was built and maintained throughout the survey noting heritage terminology for crafting incense burners throughout Dhofar.

Apart from the potters of Dhofar learning to cut the cube-shaped form of the artifact from locally acquired clay from nearby Jebel (Fig. 10), the standard cube-shaped incense burner was decorated with patterns incised into the clay onto each of the four sides of the cube. Dhofari potters engaged with design sets that were drawn from the material culture of their surrounding built environment (Zimmerle 2017a: 29; Yapicioglu and Cazacova 2016: 105). The design sets on the incense burners were inspired by the decoration of surrounding Arabian domestic architecture — hand-carved doors and windows — of the older mud-brick houses in the villages in which women potters (and their grandmothers) once lived before resettlement initiatives into concrete-made

Figure 10. *Cutting the cube-shape with horns made from local clay in Dhofar (Photographed by Zimmerle, 2018)*

Figure 11. *Old mud-brick houses, Western Dhofar (Photographed by Zimmerle, 2014)*

houses commenced in Dhofar from the 1980s onward (Fig. 11).

By visualizing the form-making processes of designing incense burners in Dhofar, multiple analogies were tested against the backdrop of incense-related archaeological finds excavated from Oman and the surrounding ancient Near East to conceive how these forms were made in the past (Zimmerle 2014: 337). Whereas the cuboid shape of the incense burner is widespread throughout southern Arabia today (specifically, the regions of Dhofar in Oman, the Hadhramawt, or eastern parts of Yemen, and as far as the island of Socotra), the designs on these forms favour seeing them as locally made and regionally cartographic specific, a point which was likely the case in antiquity given the specialized designs on cuboid incense burners

Figure 12. *Dhofari incense burner, Salalah Handicrafts Center, Salalah (Photographed by Zimmerle, 2014).*

that were also cartographic specific to the regional patterns of other pottery finds.

The built language of pattern-designing served as a syntactical program for developing the incense burners' decoration. Some of the designs including Xs and triangles were like the patterns found on the ancient forms. This is likely the result of wooden and seashell tools and tooling combined with the geometric designs repetitively made from form to form. Indeed, some of the architectural features were extracted from architectural designs in Dhofar as the case of the Bin Ali tomb near Mirbat whose dome-like structure was repeated on at least one type of frankincense burner from Dhofar (Richardson & Dorr 2003: 40). Once a potter started the process of crafting an incense burner, she would then engage in a cognitive decision-making process whereby she proceeded to execute indigenous patterns that would unconsciously make sense to her and her contemporaries in Dhofar from seeing the body of the incense burner realized as an architectural form created before her eyes (Fig. 12).

In summary, it was mainly a matter of learning by doing for craftswomen (Ingold 2013: 52). Even if Dhofari potters engaged in producing new forms, types, and designs, they continued to always make the older ones, such as cuboid shapes, as this standardized shape was recognizable in their training sessions by teaching replicated steps. Through imagining and designing the incense burner as an interchangeable process generated from an explicit set of principles for making a shape that forms a chain of provenance beginning with collecting the clay, and coiling and incising, to painting and selling the finished artifact, the Dhofari potters compensated for the restraints at work in each step by hand molding the forms. The finished product was always a weighty modeled form with an open reservoir for the smoking of viscous gum-resins which would rise upward unto the heavens when burned.

As an aside, the wide, deep, and depressed basin of a cube-shaped form is conducive to burning significant quantities of frankincense and very suitable for reuse as cleaning them is feasible because of their wide-open dimensions. Given their sizes, they are easily stacked for transport, are replaceable by clay if they become broken or unusable, and can be moved around for censing the body, a specific space, or an open venue skillfully by way of fitted handles, which evolved as modular modifications sometime earlier than the Islamic period.

Three examples of pre-Islamic cuboid incense burners, each one with a fitted handle, likely prove this

point. First, there is a fragmented clay cuboid incense burner from the 1923–1925 'Ophel' excavations in Jerusalem (nos 852–853) whose resinous remains were recently identified with Liquid Chromatography-Mass Spectroscopy (LC-MS) as having the chemical features of *Boswellic* acid (triterpenoid) (Zimmerle 2024: figs 6.1–6.2, with Total Ion Chromatograms, figs 6.3–6.5).[5] Second, there is a stone incense burner with its fitted handle (AEH 192) dated from Achaemenid Persian-Hellenistic fill at the site of Tell Maresha in the Negev, which was previously on display at the Hecht Museum in Haifa. Finally, a late Iron Age (1st century BCE–1st century CE) incense burner (S452), also with a fitted handle, was excavated at Khor Rori (Sumhuram) in Dhofar, Oman (Lombardi, Buffa & Pavan 2008: 323). The latter is only one of an exceptional array of incense burner artifacts discovered at Sumhuram from multiple seasons of excavations between the 1950s and 2000s.

Sumhuram: the incense burners of Khor Rori

When considering all the pre-Islamic sites in the southern Arabian Peninsula that have been excavated so far, Sumhuram (Khor Rori), the coastal frankincense coastal depot in the late Iron Age lying forty km east of the city of Salalah, has a significant tally of incense burners in its assemblage of archaeological finds from multiple seasons of excavations since the 1950s until today (Lombardi, Buffa & Pavan 2008: 317). Given its proximity to the lagoon for frankincense export as an inlet on the Indian Ocean, and close to the original cultivation areas for frankincense cultivation as discussed above, this is not surprising, as there was perhaps a manufacturing centre at the settlement for producing incense burners given the discovery of pottery kilns in 2015 (Rizzo et al. 2022: 283), or the pottery assemblages found at nearby Iron Age settlements such as one of the Taqa TA sites (Zarins 2001: 86–90; Pavan 2017: 6).

Initial excavations at Sumhuram, a port for the incense trade, began in the 1950s under the auspices of the American Foundation for the Study of Man (AFSM). J. Hassell has already cataloged sixteen forms from the early excavations (Hassell 2002: 157–159) noting the diversity of its assemblage at the site which include some cuboid but more shaft ones evident in the group. The ones that he identified are squat with four legs comprising of a decorative feature of incised cross-hatched pattern painted with a red coloring that is also found on forms from Tamna's cemetery in Yemen (Hassell 2002: 174, 181; Pavan and Esposti 2016:30). Based on these finds, this design pattern and decorative color seems unique to the cuboid incense burners of the late Iron Age Arabia.

Larger shaft altars, small cuboid and rounded incense burners, and mortars were also excavated from the multiple seasons at Khor Rori by the Italian mission since 2005. Lombardi, Buffa and Pavan have provided a basic tripartite typology for the altars found in their excavations (2008: 318–321). This typology includes the following: Type I) composite burners; Type II) squared burners; Type III) circular burners. Accordingly, Types II and III were further defined by being either squat, tall, legged, or legless.

The diversity of sizes and decoration varied from burner to burner at the site. For Type I, they describe it as the 'so-called portable incense altar, a typology widespread diffused in South Arabia, and very probably specific and peculiar to this geographic area' (Lombardi, Buffa & Pavan 2008: 318). These are generally shaft or pyramidal-shaped altars with a cuboid raise crowning along with stylized decorations (Lombardi, Buffa & Pavan 2008: 318–319). Three burners of this type (Pavan and Esposti 2016: 29, S1197, S1200, cat. 8–10) were found in the US281 Period I phases. Two of them were excavated 'on top of small prismatic elements with high relief snake (S1494, S1495, cat. 17–18)' (Pavan and Esposti 2016: 29). For Type II, three square incense burners of the small, cuboid shape were found (Lombardi, Buffa & Pavan 2008: 319). These included small cuboids, simple squared containers either with legs or without them. The bases were flat and set on four cuboid legs that were cut in angular form. Type III was the most intriguing of the incense burners and probably the most overlooked set of artifacts. These small, circular incense burners were the most found at Sumhuram. The excavators wrote: 'Out of the forty-seven pieces discovered over the two missions, there are fourteen pyramidal bases, six cuboid-shaped and twenty-seven circular shaped

[5] The discovery of triterpenes indicating boswellic acid from GC-MS analysis of resins extracted from the Tell Arad twin altars also serves as evidence for the trade of frankincense (as well as purportedly cannabis) in the southern Levant as early as the middle to the late 8th century BCE (Arie, Rosen & Namdar 2020: 5, 8, 10–14).

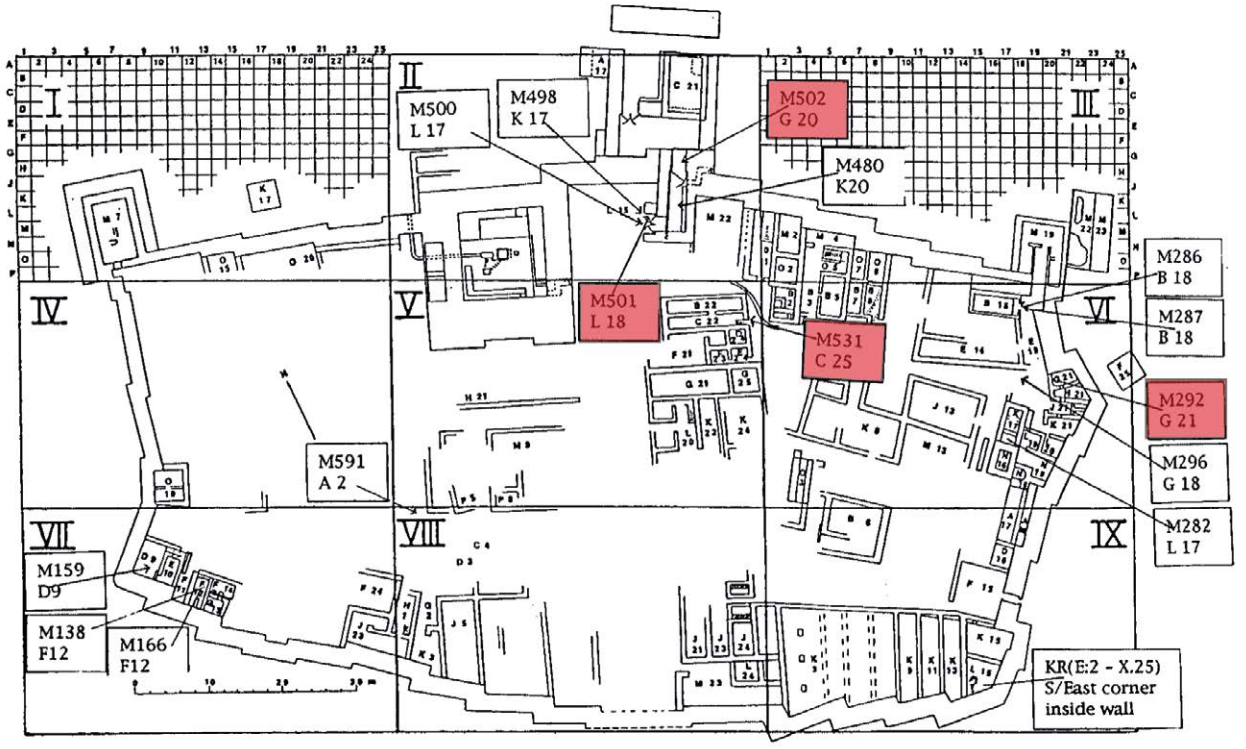

Figure 13. *Incense burners at the citadel of Sumhuram with marked findspots in red of cuboid incense burners (Zimmerle adapted from Hassell 2002:138 which was adapted from Albright 1982: pl. 4).*

incense burners' (Lombardi, Buffa & Pavan 2008: 319). The number of legs on this form can vary from three to four. The type was undoubtedly the result of local production, the result of Sumhuram craftsmanship, as demonstrated by an unfinished piece found at the site (Lombardi, Buffa & Pavan 2008: 319).

The burning of incense at Sumhuram was done at all liminal spaces by these three types of incense burners across the settlement, including at the city gate, a custom also known at other sites in the ancient Near East (Searight, Reade & Finkel 2008: 88). Five incense burners were found inside the main gateway, and larger cuboid shaft incense altars lined the exterior of the site, for the burning of incense at every liminal space, and along walking places. Within the domestic spheres, numerous stone incense burners were recovered from Room A110. This residential quarter, which stood in front of the monumental building, contained many private buildings, all of which were homogeneous with multi-storied houses. Fireplaces and workshops also dotted the domicile floor plans, indicating multiple workshops for stone and metal crafts, and the demand to always fumigate the spaces against malodors is evident by the plethora of incense-related finds.

The overall spatial distribution of the incense burners at the site produced interesting results congruent with the placement of incense burners at sites in southern Mesopotamia, the eastern Arabian Peninsula, and the southern Levant. At these settlements, small, portable, incense burners were found not only found inside houses, underneath houses, and in graves, but also along town streets where incense was regularly burned to fumigate the air neutralizing malodors and negative spaces (Fig. 13). At Sumhuram, one pyramidal-based burner (M498) and one shaft incense burner (M500) stood inside the gate along the street (Hassell 2002: 165).

Figure 14. *Cuboid incense burner with criss-cross/cross-hatched pattern, Al Baleed Museum of the Frankincense Land, Dhofar (Photographed by Zimmerle, 2023)*

Another pyramidal (M480) and two small portable incense burners as well as a cuboid burner with four legs (M501) and a circular form (M502) were all found inside the gate complex (Hassell 2002: 160, 164). In the north-eastern quadrant of the town, five incense burners were found in the administrative section, two similar pyramidal-cuboid incense burners (M286 + M287) were excavated from corridor E19 and outside B16, and a small round incense burner south of the corridor (M296) was also retrieved (Hassell 2002: 165, 162). Incense burner M282 was found in Room VI G 21, a basement corner room opposite a freestanding defense tower (Hassell 2002: 162). It was described as a unique form, a five-column-based incense altar, found in the fill north of the watchtower in Room VI L 17 (Hassell 2002: 163). Nearby, in the south-east quadrant of the city was another pyramidal-based burner found in a plastered basement room inside the town wall. Although almost all the burners were made of stone, one terracotta burner (M166) was found along with a pyramidal-based stone burner (M138) in Room VII F12, in the south-west quadrant of the town (Hassell 2002: 166–167). Finally, another four-legged cuboid burner (531) was found outside room C 22 discovered as a pair alongside a pyramidal burner (M591) (Hassell 2002: 164, 166).

Furthermore, in the southern part of room A108, a cuboid incense burner with very short legs (S1162) made of chalkstone decorated with a cross-hatched pattern was found. This similar decorative pattern is found on almost all cuboid incense burners at Khor Rori (Fig. 14). A vertical-shaft incense burner (S1128) was also found in Area B, room A73 with the same cross-hatched pattern. Based on other exemplars, the pattern seems localized at sites in the southern Arabian Peninsula (Italian Mission to Oman 2007).

Recently excavated incense burners have also shed light on the cultic and worship practices at the depot of Sumhuram. The carved representation of the Semitic lunar deity Sîn on incense burners dominated the assemblage (Avanzini & Pavan 2011: 54, fig. 13c) as well as some unique images on one incense altar, which has a lion flanked by two ibexes ornamentally carved in high relief on its frontal facade (Avanzini & Pavan 2011: 54, fig. 13a). This artifact was excavated from a small religious shrine, which seems to display an intercultural regional decoration, and is now on display in the new Oman Across the Ages Museum in Manah.

The repeated occurrence of the cube-shaped form as its multiple individually styled variances point to the multivariate purposes for these forms to purify and cleanse both hygienically and spiritually the air, and to offer its recipients hospitality and grace (Fedele & Antonini 2021: 662–664). Some people in antiquity might have integrated practicing piety and hospitality while protecting themselves wherever they went with incense in tandem with the spoken words of prayers. Using sense producing objects such as incense burners with resins seems to have become a more common practice by the late Iron Age as aromatic commodities were widely available economically because of intensified caravan trade. Neo-Assyrian royal sponsored attacks on caravans carrying *riqqū kālama* (Akk.), ŠIM.MEŠ and ŠIM.ḪI.A (Sum.), or 'all kinds of aromatics' emphasize the quantity and diversity of caravan loads traversing through the desert (Zimmerle 2020: 33). Caravan trading activities along the incense roads continued into the Achaemenid Persian, Hellenistic and Roman periods, and in the latter years under the Roman Empire, the movement of aromatics was accomplished by maritime trade. From a practical standpoint, the function of

the incense burner was to repel insects, neutralize malodorous smells that penetrated spaces, and beautify the body. As prized pharmaceutical agents, the resins were especially lucrative for their time as they were transported from Khor Rori to the Mediterranean markets of Rome as luxury commodities.

The south-eastern and eastern Arabia Peninsula assemblage of incense burners

Beyond Dhofar, late Iron Age cuboid incense burners have been discovered in the eastern Arabian Peninsula at Salut, a site in the A'Dakhiliyah Governorate, in the Sultanate. Iron Age discoveries at the site included a fragment of a terracotta four-legged incense burner (only one leg remains) with geometric designs incised on it, like the designs on associated pottery at the site (Sedov 2010: 106). The Office of the Advisor to His Majesty the Sultan for Cultural Affairs of the Sultanate of Oman (2010: 12, 26) dated the Iron Age incense burner between 600 and 300 BCE. The decoration included five raised zigzag lines forming a half-rectangle pattern (Salut 2010: 26). In the excavation season of 2011, a second incense burner (US559) was found on the southern slope of the site in an erosion layer. This exemplar was fragmentary but consisted again of a deeply incised decoration. It was dated to a similar chronological range, ca. 600–300 BCE.

Outside of the Sultanate in the neighbouring United Arab Emirates, seven fragments of cube-shaped burners and one whole form have also been excavated. One is from Rafaq in the Wadi al-Qawr (Ra's al-Khaimah Emirate) in the United Arab Emirates, another is from Rumeilah, near the Al-Buraimi and Al-Ain oases along the Sultanate's border (Fig. 15), as well as a third one from a mortuary assemblage excavated at Dibba (Boucharlat & Lombard 1985: 61, pls 65:2, 73:1; Muscat Daily 2022). A small assemblage of incense burners has also been excavated at the site of Mleiha (Fig. 16), which is about seventy-five km south-west of modern-day Sharjah in the United Arab Emirates as well (Jasmin 2001: 117–119). Two of these forms are the side legs of cuboid burners (Taha 1974: pl. IIb). One complete cuboid incense burner was found in the third occupation layer from ongoing excavations at the site (Jasmin 2001: 117–119, 123, fig. 28). A zigzag decoration was incised through the mid-section of the burner. Associated

Figure 15. *Incense burner from Rumeilah, south-eastern Arabia, United Arab Emirates in the Al Ain Museum (Photographed by Zimmerle, 2012)*

Figure 16. *Incense burner from Mleiha, south-eastern Arabia, United Arab Emirates in the Sharjah Archaeological Museum (Photographed by Zimmerle, 2017)*

finds from the site indicated that Mleiha was occupied from the second century BCE through the first century CE. Given its presence in the late Iron Age, it likely developed into a prosperous oasis much like the case of

Figure 17. *Incense burner from Thaj, National Museum of Saudi Arabia, Riyadh (Photographed by Zimmerle, 2014).*

Figure 18. *Incense burners from Qal'at al-Bahrain, eastern Arabia, Kingdom of Bahrain, Moesgaard Museum (Photographed by Zimmerle, 2014)*

Al Ain but on a lesser scale, as excavations to date have revealed a thriving culture along the Buraimi Oasis. The two incense burner fragments as well as the complete vessel were found in a layer with other craft and economy-related objects including loom weights, and ritual objects such as clay human figurine heads. Finally, one cuboid incense burner (BQ108 in area BQ) was found from Hellenistic strata at ed-Dur in Emirate Umm al-Quwain in the United Arab Emirates, a grave site that stretches for three to four km along the dunes above the lagoon (Haerinck 1994: 193). The incense burner was dated to the late Hellenistic period–1st century CE and was decorated with a geometric zigzag-wedged motif such as the type found incised onto the many cuboid incense burners at the site of Thaj (Fig. 17), indicating this design pattern was unique specifically to the south-eastern Arabian Peninsula.

In the case of Hellenistic Thaj which lies further to the north in eastern Arabia, where many incense burners were found, the design pattern consisted of wavy, curvature lines both vertically and horizontally depending on the height of the incense burners (Bibby 1983: 20, fig. 11; Al-Hashash 2002: 19–21). On the same level where some of the cuboid burners were found, there were terracotta figurines of camels, sea animals, and snakes, and human figurines, including a bearded man with large facial features, a swollen nose, sharp eyes, and thick eyebrows (Al-Hashash 2002: 19–21). The incense burners might have been used ritually along with the figurines.

Finally, small cuboid burners were also discovered at Qal'at al-Bahrain in the Iron Age stratigraphic phases. Cuboid incense burner 520.KK, the earliest datable burner from Bahrain was found in a post-Kassite stratum, specifically Period IIIC (1000 BCE) (Højlund & Anderson 1997: 183). It was squat and had no legs. Object 519.BJJ was found in the eastern part of the excavation where layers dating to Period IIb/c were overlain by layers dating to Period IVb (Højlund & Anderson 1997: 183, 187). However, the two incense burners appear to be similar and their geometric punctuated marks or decorations were perhaps made with the head of a reed stylus, or a similar type of tool (Fig. 18). Cuboid incense burners from later periods at the site (Achaemenid Persian) with four legs were incised with geometric motifs and designs such as triangles (Højlund &

Anderson 1997: 101, 183, 187; Højlund & Anderson 1994: 185, 363, 478–479) and punctuated marks.

Along the western overland incense trade routes running northward from south-western Arabia, one finds a multitude of newly excavated incense burners at archaeological sites such as Najran, Qaryat al-Faw, and Tayma. Some are plain but many exist with geometric patterns such as punctuated marks. Additionally, many of these cuboid artifacts are unique in form. At Al-Faw, for example, two incense burners were constructed of three interconnected cubes shaped from one block of stone (Al-Ghabban 2010: pl. 75), and a more recent cube-shaped form excavated from a mortuary tomb at Dadan was crafted as two connected cubes from one block of stone. Gas chromatography analysis of the incense burners excavated at Dadan also resulted in the chemical features of frankincense, on the one hand, but also conifers in greater abundance, on the other (Rohmer 2024).[6] The individuality of these forms point to diverse and innovative local traditions and architectural adaptations to the idea of the original cube-shaped form, emerging along the Arabian incense trade roads from as early as ca. 600 BCE.

Beyond the Iron Age: medieval Islamic cube-shaped forms in the southern Arabian Peninsula

Having reviewed the totality of evidence known from excavations in the south-eastern Arabian Iron Age, it is unknown how far back the tradition of crafting clay cube-shaped incense burners date especially when one considers that the entire incense burner and altar assemblages at Khor Rori and at the other sites listed above, were mostly made from stone. However, it also seems that the transition in medium from stone-making to clay-producing incense burners occurred at least in Dhofar sometime in the medieval Islamic period as two incense burners (a rounded one with a broken handle and a cuboid one with connecting four legs and a flat base) are on display from excavations at Al Baleed in The Museum of the Frankincense Land in Salalah (Pavan & Al Kathiri 2021: 129, fig. 12). Incense burners of this type with four long legs and a base were found with shisha pipes in the latest excavations of the last occupational phase-strata, Phase VI (1650–1800 CE) at Al Baleed, when it served as place of major coastal trade (Pavan et al. 2018: 214). Even earlier phases, such as Phase IV, when Al Baleed was the most splendid and largest of its size as flourishing under the Rasulid Dynasty, were incense burners found with 'dot-in-circle' motifs similar in shape and decoration to the burners found at the harbor site, al-Shiḥr in its 14th-century CE strata (Pavan et al. 2018: 216; Fusaro 2019: 137; Le Maguer 2011: fig. 5).

Comparatively at the site of al-Shiḥr, in the Hadramawt of Yemen, about 700 km south-west of Dhofar, the evidence for clay cuboid incense burners crafted comparatively with the same designs date to the 1250 and 1550 CE. Claire Hardyv-Guilbert and Sterenne Le Maguer have shown that an evolved four-legged incense burner like the RJ-2 form can also be found in the 9th–11th centuries CE at al-Shiḥr (Hardy-Guilbert & Le Maguer 2010: 65). Additionally, one should note that the various sub-types of the four-legged and flat-based, legless incense burners of the cuboid form with windows, dominated the assemblage from the 15th–19th centuries CE. The incense burners found in the latest strata (1550 CE) were incised with wedged-shaped indentations and incised lines, and earlier incense burners with 'dot-in-circle' motifs incised on their bodies and along their handles were found in levels from 1250–1450 CE (Hardy-Guilbert & Le Maguer 2010: 74, 79).

As a final point in the sequence, the types of rectangular or cube-shaped incense burners produced today in Dhofar matches Type 4c (horned cube-shaped with four legs and a plinth) and Type 5a (horned cube-shaped with base and a square window) at al-Shiḥr, which are dated to the 15th–16th centuries CE, and the 17th–19th centuries CE, respectively (Hardy-Guilbert & Le Maguer 2010: 65). All forms from those periods retain horns or protrusions moulded in clay or carved in stone at their four corners.

In summary, the oldest type of incense burner found at RJ-2 discussed at the outset above, coupled with a typology of incense burners published at al-Shiḥr and the ethnographic evidence from Dhofar today, reveals a

[6] One form from Al Faw is on display at the King Saud University Archaeology Gallery. The other form from Al Faw (No. 141 5 F 13, Dept of Archaeology, King Saud University, Riyadh), of more pristine condition, completed with an incised decoration of a lunar crescent, was on display at the Roads of Arabia exhibition (Al-Ghabban 2010: pl. 75). The Dadan incense burner was recently excavated from a mortuary context by J. Rohmer (November 2022). It is reported that the chemical features of *Boswellia* from its resin were analyzed as well as conifers through organic residue analysis (Rohmer 2024).

full sequence of the evolution of cube-shaped incense burners in the southern Arabian Peninsula from antiquity to the present day.

Summing-up: Dhofar's incense burners entangled with frankincense

Returning to Cleuziou and Tosi's excavations of the earliest incense burners, as they both noted that frankincense burning was a 'normal part of sociability' in Omani today, they described in detail the findspot for the sandstone artifact found in the corner section of the room emphasizing the value of frankincense for incense burning today:

> Last fumigation had been done a little time before leaving the house, and a patch of greasy burnt material at its center could be identified as the residue of burning some mixture of aromatics, probably frankincense. When people came back to Ras Al-Jinz, the walls of the room had fallen (Cleuziou & Tosi 2020: 353–354).

As a last ethnographic note on how cube-shaped incense burners in general functioned in multipurpose ways for many people in multiple contexts throughout the ages, a photograph from Bertram Thomas' travels through the Empty Quarter in the 1930s helps us to anchor the typology of cuboid incense burners in Dhofar to at least the first half of the 20th century and provide additional evidence of the use of this form in its time as a way of ethnographic analogy. In one of his images from the foot of the Jebel, Thomas had photographed two Dhofari men alongside a bovine (Zimmerle 2017a: 33; 2018: 308, fig. 15.9). In the hand of one Dhofari man is a cube-shaped incense burner. From the photograph, he appears to waft and ambulate the incense burner full of *lubān* (frankincense) around the head of the animal. While we do not know the grade of frankincense at the time, one assumes it was the highest quality, as this grade was the frankincense type reserved for exorcisms and to cure the sick (Zimmerle 2017a: 33, fig. 14). Thomas writes of this experience specifically in his reports:

> The incense burner was brought, and wood was introduced and lighted. The practitioner, the cow-owner, broke a fragment of frankincense about the size of a walnut into three pieces. Then spitting upon it three times he introduced it into the burner. While two other witnesses held the afflicted animal by head and leg respectively, he waved about its head the burning frankincense, chanting a set sacrificial chant (Thomas 1932b: 88).

While the actual 'chant' is unknown, a mid-20th century daily prayer in Dhofar directed towards the burning of frankincense was:

> O, Frankincense (Ya lubān)! O, Frankincense! You the one who is going to the heavens; keep away from us, the enemy" (Zimmerle 2020: 40).

Indeed, after gazing at this photograph, archaeologists working in northwest Arabia may be reminded of the images on one of the most outstanding artifacts to have been discovered in excavations inside the Kingdom of Saudi Arabia, the al-Hamra cube. This artifact has yet to be fully understood in the complexity of its limited programmatic images when one circumambulates

Figure 19. *'Al-Hamra cube' from Tayma: man standing in front of a marching bull (compare Fig. 2 in the 'Introduction' for the other side of the cube) (© DAI Orient Department, and Heritage Commission, I. Wagner)*

the two sides of the cube. How the panels on the cube should be understood as an interlocking visual narrative (Fig. 19) remains elusive and vague, although each image is comprehensible. Recently, a variety of positions have been discussed in scholarship and Arnulf Hausleiter has described the cube's images in the best following manner:

> On two of its four sides, there are ritual (offering) scenes with a priest oriented toward a bucranium, or bull with a disk between the horns. Whether the two remaining sides once bore inscriptions (ostensibly in Imperial Aramaic) or further images is unclear but can probably be ruled out considering the position of the object within the room (Hausleiter & Lora 2021: 154; see also Bawden, Edens & Miller 1980: 147, fig. 10).

Carved basically into stone, one side of the cube displays a man standing before a marching bull. But similar in many ways to Thomas' photograph, he holds a ritual object or an offering-type in his hands that visually appears to be presented before the animal. The other side displays the head of the bull positioned on the flaming-smoking altar, presumably as a sacrifice.

Although the environmental contexts are undoubtedly dissimilar both temporally and spatially with over 2000 years apart in time, and with a geographical distance of over 3,000 kilometers between Dhofar in the Sultanate of Oman and Tayma in the Kingdom of Saudi Arabia, Thomas' black and white photograph where the head of a non-lactating or dry bovine is censed offers a rare glimpse into the portrait past of pastoral life in the Dhofari mountains during the first half of 20th century. The captured event may be used to further reference some analogies that would shed light on cultic life in Iron Age Arabia tying together themes of sacrifice, incense, and prayer on the al-Hamra cube. Joy McCorriston has interestingly applied ecological models to cattle shrines and pilgrimages in her analysis of ancient Arabian societies, writing that "the practice and ritual offering nearly universally requires prime, healthy animals. These are animals most nearly like the qualities of the divine for which they stand and must be near perfect" (McCorriston 2011: 105; Hubert & Mauss 1898: 125; Chelhod 1955: 75, 126, 151).

Herd management in Dhofar was indeed likely dependent upon traditional methods of grazing, health, farming, and pharmacology using natural resources such as fumigating the head of the beast with *lubān* (frankincense) to stimulate lactate production between dry periods. Acting as a potential cure before the sacrificial slaughter if frankincense did not yield therapeutic results, the gum resin as fumigant also afforded protection and positive agency in the community from negative supernatural forces like an attack by the supernaturally believed 'evil eye'. On the cultural beliefs once practiced in Dhofar, a British General wrote the following observation in the 1940s about a decade after Thomas' account:

> A Bedouin of the 'Bait Katan' section averred to me that travelling at night he was once dogged by an old hag who when threatened with a sword, retired growing larger and larger until she was transformed into a tree. Another said he heard jinns in the running streams at dusk while a youth who was produced before me, alleged to be possessed of a jinn, appeared from his father's descriptions of his actions to be a somnambulist (British Library 1943; Owtram 2014).

Undoubtedly, supernatural possession was believed by the local population in Dhofar as found in subsequent ethnohistorical diaries and accounts after Thomas' report. Pre-modern ways of thinking would account for the use of traditional pharmacology like the natural resource *Boswellia* growing in Dhofar as natural remedies acting potentially as anti-inflammatory agents (Langenheim 2003). Indeed, Bertram Thomas described the ritual of frankincense burner vividly in detail when describing the bovine in the mountain: 'These mountain tribes are much afraid of the Evil Eye, not only for themselves but equally for their flocks and herds. The ceasing of lactation is invariably ascribed to Ain Balis. The cure is frankincense' (Thomas 1932b: 88).

Conclusion

The essay began with a chronological framework emphasizing archaeologically the provenance of the earliest incense burners in the Arabian Peninsula. It then traced the handicraft tradition of incense burner

making commencing with the ethnographic record of the Sultanate in contemporary day, emphasizing almost five thousand years of cultural continuity for how one incense burner form evolved and subsequently became an output as a marker of the famed Arabian trade of frankincense. This cube-shaped form, one of many types of incense burners, but a dominant one in the assemblage of pre-Islamic incense burners, was found in significant quantities around the southern Arabian Peninsula from every quadrant of the pre-Islamic Middle East. Over time, it became the standard portable way to beautify the domestic, the mortuary, the self, and much of the surrounding material world, including sensing jewelry, the physical body, the home, and ones' clothes through the application of wafting burning gum resins and other aromatic mixtures that were available locally, and in circulation regionally, via the long-distance trade routes of antiquity (Zimmerle 2018: 309).

Summarizing much of the evidence presented above, Dhofari potters, much like the women potters found still living and working today in the Hadramawt of mainland Yemen, are all form-makers. This ultimately means that they all craft their pottery forms from the unconscious self. In such traditional societies, the same or similar terracotta forms are replicated repeatedly as an extension of the potters' dexterity by doing and, of course, by rote. However, this does not mean that innovations are neglected. These forms are replicated intergenerationally from house to house throughout Dhofar genetically, and any modifications were required and encouraged in the general form-principles for function-making as indigenous knowledge. This is demonstrated often visually and ethnographically by how potters conceived their personal identities as makers and sometimes as innovators, when we find cases where they created a maker's mark on the bottom of an incense burner, or when they created new forms like Ghalia did, outside the boundaries of older ones. In short, as potters they have consistently overtime contributed small, evolutionary modifications while retaining the attributes of the original cube-shaped form.

We can reiterate these final points again when recalling stages from Zeina al-Noobi's interview mentioned above at the commencement of this essay, where she emphatically stated, 'I come up with new and different designs and make them, but always find myself going back to the traditional styles.' In this sense, incense burners formed and designed as decorated cube-shaped containers served as one type of a 'frankincense' incense burner in both the memory of and in the execution by the hands of pottery makers. On the one hand, these forms are simply the testament for wherever the trade routes ran in antiquity; on the other, their open shapes with flat bottoms or legs for either holding or placing the object around rooms and spaces worked well functionally for gum resins, which are highly viscous, dried and hard to clean from surfaces after burning.

As a final ethnoarchaeological analogy, one key to understanding the development of incense burner production in Arabia lies with Thomas' photograph and the date it was photographed. At least one type of an incense burner from the early 20th century (1930s) that the Dhofari gentleman holds in Thomas' photograph matches the cuboid form still produced today in Dhofar (Zimmerle 2017a: 33, fig. 14). This is one example of how ethnographic evidence in the form of an older photograph may be used to illustrate how material culture moves through history.

In summary, Dhofari *majāmirah* are touchstones of the historical past formed by the unconscious selves of the potters. They were modeled in a miniature architectural design after the built environment and form innovative containers to hold and house burning natural resources such as frankincense, and other luxury perfume mixtures. Both these natural resources and exotic substances were trafficked overland and by sea through the south-eastern Arabian Peninsula corridor in antiquity. Their legacy continues in traditional form and function as living tangible and intangible heritage in the lands where frankincense species grow.

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Outlook: the scents of Arabia – a 'nose-on' approach

Sofia Collette Ehrich

Summary
This chapter responds to the perspectives presented in these proceedings for the Seminar for Arabian Studies. By using an anthropological approach, it presents a means for us to better understand our cultural and innate bias to neglect our sense of smell. A nose-on approach brings forward the limitations and opportunities for future research and lays a foundation for moving forward. This outlook especially focuses on the rich opportunities that can be found within the scope of Arabian archaeology and Smell Culture Studies, which can be applied to a variety of disciplines.

Keywords: olfaction, smell culture, olfactory heritage, museology

Our sense of smell (olfaction) is arguably one of the most important ways in which we experience the world. However, it is also our most overlooked sense in terms of historical research: in art, history, science, culture, and education (Reinarz 2014). That is not to say that olfaction has not played a prominent role in the past, but it is often neglected and attributed to an impulsive act of passion, emotion, or luxury (Classen 1999). Arguably, scents are thought of as merely things which we apply to our body as perfumes, a luxury product to be purchased and displayed on bathroom shelves or a marketing ploy that has the power of manipulation.

But I would argue that smells are more than this. Smells — as well as our olfactory sense — are an integral part of our own cultural identity, a constant variable in our everyday life. This should not be a surprise as olfaction is the only *classic sense* (sight, hearing, touch, smell, and taste) which has a direct link with our brain's limbic system, meaning that when we sniff something, it immediately triggers our memory and emotions (Levent & Pascual-Leone 2014). We could say that somewhere in our subconscious mind, we all have a toolbox of scent memories available at will.

Yet, our sense of smell remains undervalued even after the Covid-19 pandemic when olfactory loss and dysfunction was not only a persistent symptom of the illness, but these effects also made a long-lasting impact on its victims (Elkholi, Abdelwahab & Abdelhafeez 2021). In her study of over 400 individuals in 2021, neuroscientist Dr. Rachel Herz found that people were more willing to give up their sense of smell over their sense of vision and hearing (Herz & Bajec 2022). Furthermore, these individuals would rather lose their sense of smell than their smartphone, streaming services, social media platforms, or the opportunity to take their dream vacation (Herz & Bajec 2022). This is the case, even though losing our sense of smell can have a drastic impact on our lives. Anosmia (and its related forms) have been linked to genetic disorders, dementia, Alzheimer's disease, and depression (Fang et al. 2021). Herz is one of many who are raising awareness around the impact that losing our sense of smell can have on our health, longevity, and wellbeing as well as creating spaces for patients to access reliable information about their condition.[1]

Is there a reason for this persistent and seemingly innate bias of olfaction? It could be partly due to the well-established, western *ocularcentric* tendency to undervalue our sense of smell and its related attributes, something that anthropologists Constance Classen and David Howes call the "Western hierarchy of the senses" (Classen 1993). Using Aristotle's model of the five classic human senses, this hierarchy claims that the western world favors the audiovisual senses (the so-called 'higher senses'), while placing lesser worth on the senses of taste, smell and touch (the so-called 'lower senses') (Classen 1997). Classen and Howes claim that

[1] I refer here to initiatives like AbScent (United Kingdom), The World Taste & Smell Association (United States), and STANA: Smell and Taste Association of North America.

there is not only a clear distinction amongst the senses but also that this distinction forms an ideology which deeply impacts how we utilize and value all our senses. This makes sensory perception not just a physical act but also a cultural one (Classen 1997).

However, in 2025 we find ourselves in an olfactory renaissance, a time when many are researching, experimenting, and celebrating the enormous potential of olfaction. Particularly interesting for these proceedings are research initiatives dedicated to uncovering and preserving our olfactory history and heritage and using these research outcomes to inform the public about sensory histories. Some examples include the Odeuropa project which was active between 2021 and 2023 and the ODOTHEKA project which has been active since 2022. Both projects dedicate(d) their research to uncovering olfactory heritage and histories of Europe with a specific focus on reproducing these scents to interpret the collections of cultural heritage institutions, bringing these scents to the noses of the present in a meaningful and memorable way. The acceptance and reception of these large-scale research projects dedicated to smell and olfactory heritage legitimize and empower our sense of smell as an important part of our past, present, and future.

The collection of presentations that took place at the *Scents of Arabia* special session demonstrated the complex, intricate and influential role that fragrant materials and olfaction had on ancient Arabia's cultural identity. The session — as well as the contributions in this volume — are key as it broadens the conversation of Smell Culture Studies to ancient Arabian Studies, which has been lesser included until now.[2] In this outlook, I will take a 'nose-on' approach to reflect on the research presented in this volume. What is the importance of a 'nose-on' approach to Arabian Studies? What does the research in this volume reveal and contribute to the field of Smell Culture Studies? How does this research pave the way for new research opportunities and cross disciplinary collaborations?

A 'nose-on' approach

As Arnulf Hausleiter stated in his introductory lecture to the *Scents of Arabia* special session (see the introduction to this volume) for a long time, the fragrant history of Arabia was uncovered through the mapping out of trade routes and the uncovering of archeological sites with little attention paid to the actual *materiality* of these fragrant materials and the cultural practices that occur around them. In other words, until now much of ancient Arabia's fragrant past has been uncovered — not via 'nose-on' methods — but rather through the analysis of textual accounts and visual representations. Hausleiter's reflections on the current state of analysis of Arabia's fragrant history brings forward the importance of Dr. Caro Verbeek's *olfactory gaze* approach to art history. Verbeek's *olfactory gaze* refers to the act of analyzing art historical texts and images from an olfactory perspective, uncovering historical insights which would have remained invisible from a strictly visual perspective (Ehrich et al. 2021). In the case of the *Scents of Arabia* special session, one could argue that all scholars involved employed Verbeek's olfactory gaze but for archeology, actively engaging with and illustrating a topic directly related to the fragrant materiality of ancient Arabia.

The same goes for the authors of this volume, who demonstrate the significant role that olfactory related practices and their related fragrant materials have had in ancient Arabia. The 'nose-on' approach of these authors is validated through their deliberate sensory oriented argumentation and their consideration of the past from the materiality of fragrant materials, rather than by only validating history via written accounts or examining visual aspects of ancient artefacts. By deliberately addressing this fragrant part of ancient Arabia's past, these authors uncover unique insights, which may have remained overlooked if not analyzed using a 'nose-on' approach.

Arabia's Smell Culture Studies

This publication opens the opportunity to position Arabian Studies within the field of Smell Culture Studies. Until now, the field of Smell Culture Studies has focused on the geographical territories of Europe and the

[2] I follow the definition of Smell Studies by www.smellstudies.com which is as follows: "Smell Studies... [is] the growing field of research focusing on the sense of smell in a variety of domains. The field of Smell Studies falls under the umbrella of Sensory Studies which encompasses visual culture, auditory culture, smell culture, taste culture, and the culture of touch."

Americas. The articles presented in this volume present valuable insights into the fragrant history of Arabia and how this history goes beyond that of perfume, extending to cultural practices such as the burning of incense for the divine and other rites of passage.

I see particular potential for Arabian *archeology* to successfully contribute to the Smell Culture Studies movement for three reasons. Firstly, there is an intricate groundwork for unveiling the past via large scale archeological excavations. The wealth of history uncovered from these sites can provide rich use cases for olfactory heritage research such as perfume vessels, incense burners, storage vessels, and cooking utensils.[3] Secondly, the already stable interdisciplinary nature of archaeological research interacting with epigraphic, anthropological, paleo-environmental studies as well as other disciplines makes these scholars better equipped for olfactory heritage research, which often requires cross-disciplinary exchange. Lastly, researchers within this topic have already employed technologies used in archeological science, such as chromatography and mass spectrometry, which can more accurately detect the fragrant residues left on ancient objects. This is a game changer for olfactory heritage research as it adds a new layer to understanding the past and addressing challenges of authentically reproducing scents of the past. Employing technologies like these expands our understanding of what materials these objects may have *actually* smelled like to the noses of the past, paving new ways for the noses of the present.

Opportunities for future research

I hope that with the publishing of these proceedings comes a broadening of the scope of Smell Culture Studies as a whole, not only to include the Arabian world and its dynamic fragrant history, but also that of other cultures which are currently excluded or overlooked. My other wish is that with the broadening of the field comes further cross disciplinary collaborations between practitioners and scholars, heightening and diversifying the representation of the world's diverse olfactory heritage. A key piece of this could be the use of scents in the cultural sector — especially in museums and other cultural heritage sites.

In the last decade, it has become more common to use scents beyond their traditional use as a perfume, but also as an experimental medium for storytelling within cultural heritage sites, museums and in art (Ehrich et al. 2023; Verbeek 2016). In 2021 and 2022, Odeuropa curated four *olfactory events* where scents and historical narratives were presented to the public simultaneously — recontextualizing scent as more than merely something to be worn on the skin, but also as a keeper of knowledge and understanding (Ehrich et al. 2023). The use of olfactory storytelling can not only present heritage institutions with an innovative way of presenting and interpreting their own collections, but it can also heighten the emotion and memory of visitor – increasing their ability to recall the historical information presented later (Ehrich et al. 2023). The definition and use of olfactory storytelling within the cultural sector and beyond, was recently stabilized via the release of Odeuropa's *Olfactory Storytelling Toolkit: A 'How-To' Guide for Working with Smells in Museums and Heritage Institutions.* This publication officially defines olfactory storytelling as when 'the careful orchestration of scents and the activation of our sense of smell are used in a meaningful way to connect to the GLAM[4] environment, collection, and historical concepts of heritage practices, places, and objects.' (Ehrich et al. 2023). With these methodologies now on hand, hopefully more scholars will put them to use.

I want to conclude this *outlook* by illustrating what such cross disciplinary collaborations between scholars and practitioners look like via an example relevant to these proceedings. In 2023, Barbara Huber and I worked with perfumer, Carole Calvez, to interpret the findings of Huber's research paper, "Biomolecular characterization of 3500-year-old ancient Egyptian mummification balms from the Valley of the Kings" (Huber et al. 2023) into a scent. The paper discussed the process of Huber and her team who used GC-MS, HT-GC-MS, and LC-MS/MS analyses to better understand the fragrant materiality of the mummification balms excavated more than a century ago by Howard Carter from a Tomb in the Valley of the Kings (Huber et al. 2023). These vessels are now housed at the Museum August Kestner

[3] These objects have also been called 'scent archives' (Huber et al. 2022).

[4] GLAM is an acronym for galleries, libraries, archives, and museums.

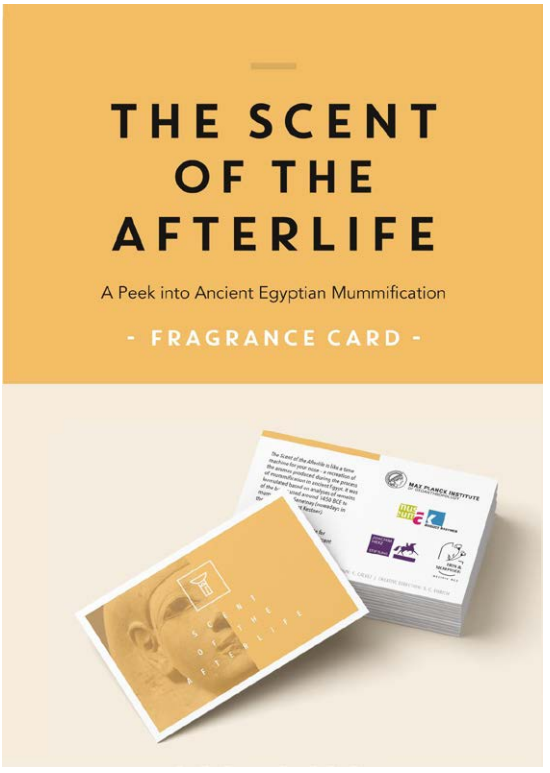

Figure 1. *The Scent of the Afterlife card. Scientific analysis Barbara Huber, perfume creation Carole Calvez and creative direction Sofia Collette Ehrich. Artwork by Michelle O'Reilly.*

in Hanover, Germany. The scent — created by Calvez — was developed from the information gleaned from the analysis of the sample of the mummification balm scraped from the canopic jar housing the organs of the noble Lady Senetnay — the high-ranking Egyptian wet nurse of Pharaoh Amenhotep II.

Thanks to the scientific methods that Huber and her team applied to the sample, they were able to come up with a list of the fragrant materials that made up the balm of Lady Senetnay. This list included beeswax, plant oils, coniferous resin, dammar or *Pistacia* tree resin, bitumen, balsam and animal fat. It is important to note that this list not only more accurately describes what the balm may have actually *smelled* like, but it also reveals the functionality and importance of these materials – for example the role they played in preserving the body for eternity. With the list of fragrant materials and the archeological context as a brief, Calvez developed a scent.

The outcome was the 'Smell of the Afterlife', a strong scent — sweet, resinous, smokey and with a strong whiff of pine. This scent was primarily meant to be in the form of a scented card (Fig. 1), but was also presented at the Moesgaard Museum in Denmark in their exhibition, *Ancient Egypt – Obsessed with Life* (2023). This exhibition allows visitors to connect with ancient Egyptian funerary practices in different ways. Firstly, they could

Figure 2. *Visitor sniffing the 'Smell of the Afterlife' at the Moesgaard Museum (Denmark) in the exhibition Ancient Egypt – Obsessed with Life. (Barbara Huber).*

read about funerary practices via wall texts. Secondly, they could use their eyes to view mummies as well as the canopic jars that would have housed their organs. And lastly, they were able to take a whiff of what such funerary balms would have smelled like (Fig. 2). The activation of multiple senses in this case offers the visitor with multiple avenues of engaging with the historical material, diversifying the type of audience it can reach as well as increasing the attention with which that material is learned (Eardley, Dobbin & Neves 2018).

Although such collaborations glean positive results, it does not come without challenges. Smell Culture Studies is an ever-growing field and so is olfactory storytelling, meaning that there is still much to learn and discover. Requiring the knowledge of scientists, archaeologists, heritage professionals and a perfumer, the 'Smell of the Afterlife' illustrates the complexity that these projects take. With the broadening of Smell Culture Studies and olfactory heritage research, we question the traditional boundaries of perfumery opening new avenues for the experimental use of scent as well as fruitful opportunities for future collaboration.

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Scents of Arabia presents an innovative interdisciplinary exploration of the role of scents and incense in ancient Arabian societies. Bringing together leading experts in archaeology, biomolecular science, sensory studies, history, and ethnography, it reveals how aromatic substances were deeply embedded in social, ritual, and economic life across time. The book challenges traditional trade-focused narratives and instead highlights the complex, multisensory dimensions of scent - as a medium of communication, identity, and religious experience. Emphasizing the cultural agency of olfaction, the contributions of this book offer new frameworks for understanding how ancient societies perceived, used, and valued aromatic substances. This volume positions olfactory heritage as a key element of historical inquiry and advocates for its recognition within broader debates on intangible cultural heritage.

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